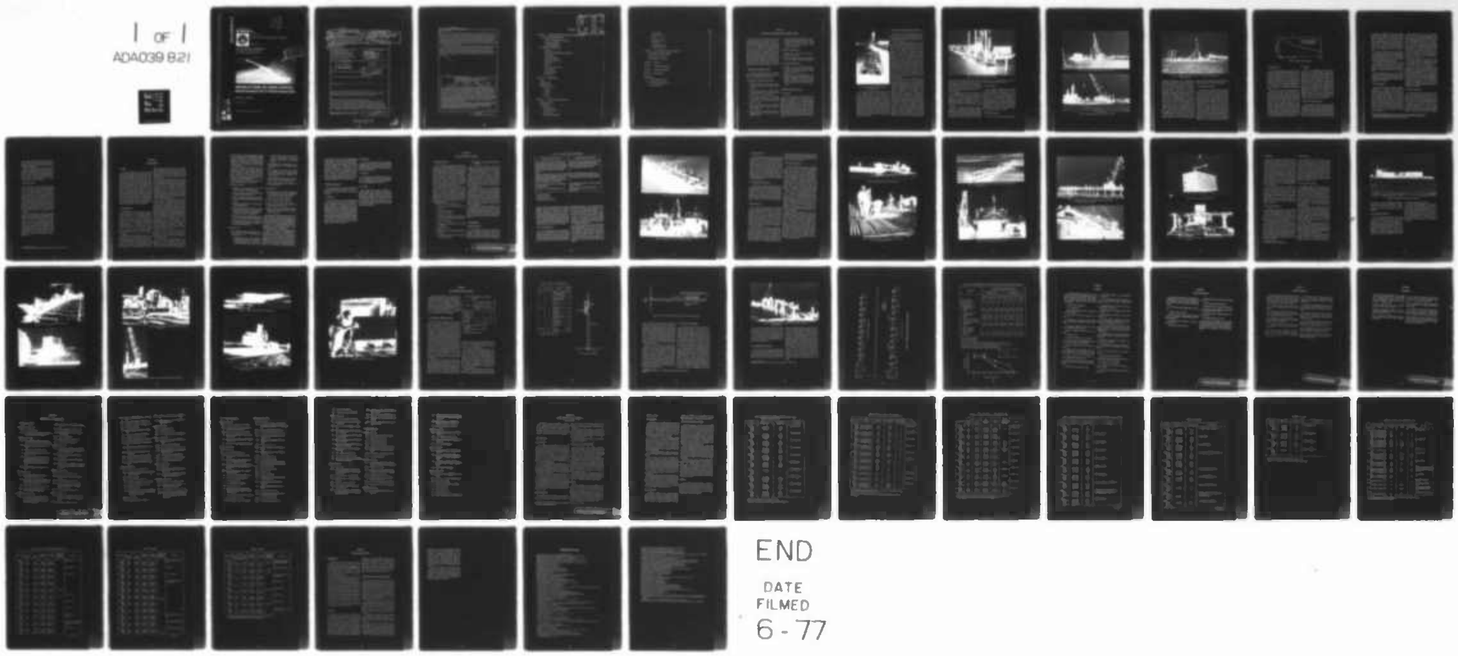
AD-A039 821 CIVIL ENGINEERING LAB (NAVY) PORT HUENEME CALIF F/G 13/13
CONTAINER OFF-LOADING AND TRANSFER SYSTEM (COTS). ADVANCED DEVE--ETC(U)
MAR 77 R C TOWNE
UNCLASSIFIED CEL-TR-852-1 NL

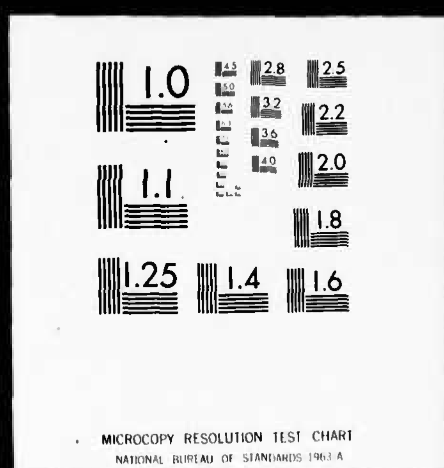
1 OF 1
ADA039 821



END
DATE
FILMED
6-77

1 OF 1

ADA039 821



Technical Report

R 852-I

Sponsored by

NAVAL FACILITIES ENGINEERING COMMAND

March 1977

CIVIL ENGINEERING LABORATORY
Naval Construction Battalion Center
Port Hueneme, California 93043

CONTAINER OFF-LOADING AND TRANSFER SYSTEM (COTS)
Advanced Development Tests of Elevated Causeway System

VOLUME I – SUMMARY

by Richard C. Towne

Approved for public release; distribution unlimited.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER (14) CEL-TR-852-1	2. GOVT ACCESSION NO. DN587072	3. RECIPIENT'S CATALOG NUMBER (9) Technical rept.
4. TITLE (and Subtitle) (6) CONTAINER OFF-LOADING AND TRANSFER SYSTEM (COTS) • Advanced Development Tests of Elevated Causeway System. Volume I • Summary •		5. TYPE OF REPORT & PERIOD COVERED ~~Not final~~ Jun 75 – Jan 76
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) (10) Richard C. Towne		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Civil Engineering Laboratory Naval Construction Battalion Center Port Hueneme, California 93043		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS (16) 63705N; Y41X6 001-01-001
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Facilities Engineering Command Alexandria, Virginia 22332		12. REPORT DATE (11) March 1977
		13. NUMBER OF PAGES 62
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) (12) 59p.		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited. (17) Y41X6 001

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Causeways, elevation, pontoons, installation, pier containers, unloading, cargo handling, off-loading, elevated causeway, lighters, containerization, Lo/Ro concept.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A two-phase advanced development test program was conducted to evaluate the installation, operation, and demobilization of the elevated causeway system. In particular, the program was to determine (a) the structural adequacy and operational capability of the elevated causeway with spudwells mounted internally or externally to NL pontoon sections, (b) the adequacy of the elevating mechanisns to raise, secure, and interface with NL pontoon

continued

DD FORM 1473 1 JAN 73 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

391 111

20. Continued

sections, (c) the practicability of transporting fenders to the site and installing them on the elevated pier, (d) the capabilities of the fenders to function as intended, (e) the capability of the elevated causeway to perform the container off-loading functions, including truck/trailer trafficability and turnaround, and (f) the practicability of expanding the cargo-unloading platform (pierhead). Also tested during Phase II was the Lo/Ro concept which delivers containers deck-loaded on a causeway ferry; the ferry is beached, and the containers are off-loaded with commercial container handlers.

The Phase I laboratory tests were conducted at an open-ocean beach site at Point Mugu, California. The Phase II tests were conducted by military operators in conjunction with laboratory personnel at an open-ocean beach training site at Coronado, California. The results of the tests verified the practicability of all elevated causeway elements to perform their individual concept functions. Crane container-handling rates of up to 20 per hour were attained.

Library Card

Civil Engineering Laboratory
CONTAINER OFF-LOADING AND TRANSFER SYSTEM (COTS) – Advanced Development Tests of Elevated Causeway System.
Volume I – Summary by Richard C. Towne
TR-852 – I 62 pp illus March 1977 Unclassified

1. Containerization 2. Expeditionary pier WU I. Y41X6-001-01-001A

A two-phase advanced development test program was conducted to evaluate the installation, operation, and demobilization of the elevated causeway system. In particular, the program was to determine (a) the structural adequacy and operational capability of the elevated causeway with spudwells mounted internally or externally to NL pontoon sections, (b) the adequacy of the elevating mechanisms to raise, secure, and interface with NL pontoon sections, (c) the practicability of transporting fenders to the site and installing them on the elevated pier, (d) the capabilities of the fenders to function as intended, (e) the capability of the elevated causeway to perform the container off-loading functions, including truck/trailer trafficability and turnaround, and (f) the practicability of expanding the cargo-unloading platform (pierhead). Also tested during Phase II was the Lo/Ro concept which delivers containers deck-loaded on a causeway ferry; the ferry is beached, and the containers are off-loaded with commercial container handlers.

The Phase I laboratory tests were conducted at an open-ocean beach site at Point Mugu, California. The phase II tests were conducted by military operators in conjunction with laboratory personnel at an open-ocean beach training site at Coronado, California. The results of the tests verified the practicability of all elevated causeway elements to perform their individual concept functions. Crane container-handling rates of up to 20 per hour were attained.

CONTENTS

SECTION 1

GENERAL RECOMMENDATIONS AND OBSERVATIONS

The following information covers general recommendations and observations and does not necessarily include all the detailed items that are covered in the individual volumes. A critique of the tests was held on 4 December 1975 at the Coronado test site, and comments and suggested system/operation improvements were presented by the military operators (Amphibious Construction Battalion ONE). This was followed by a meeting at CEL on 8-9 December 1975 with personnel from PHIBCB-TWO and PHIBCB-ONE to discuss the operation and proposed modifications. The basic agreement of all parties was that the elevated causeway system can be used in its present form as a pier for transferring 20-ton (18-Mg) containers to the beach.

1.1 GENERAL RECOMMENDATIONS

The following recommendations were presented which should significantly improve system components or the operation/safety procedures.

1.1.1 Installation Equipment and Techniques

- Modify lift padeyes on spudwells to provide a clear deck for working and to permit side-carry on an LST.
- Reduce the number of hydraulic hoses associated with the lift system to simplify handling and reduce damage possibilities.
- Revise method of attaching external spudwells onto existing pontoon sections to expedite installation of spudwells, especially when sections are afloat.
- Improve pile hammer leads to reduce damage to and necessary repairs of leads during pile-driving operations.
- Improve method of securing pontoon sections to piling to eliminate or reduce the amount of welding required.
- Provide an improved, safe ladder system for use between deck levels when sections are being elevated. (The floating section is moving vertically with the waves relative to the adjacent elevated section.)

1.1.2 Side-Connector System

- Improve the side-connector system by simplifying its operation.
- Position the components between the pontoons so as to be readily accessible to the operators.

1.1.3 Container-Handling Crane

- Employ a larger mobile crane, 140-ton (127-Mg) rated capacity. The 90-ton (82-Mg) capacity crane used during Phase II was working close to its limit.
- Investigate the use of a pedestal-type crane to replace the rubber-tired mobile crane on the pierhead. (Advantages of the pedestal crane appear to be in crane weight reduction, greater lift/reach capacity, and improved shipping ability.)

1.2 GENERAL OBSERVATIONS

1.2.1 Spudwells

The two types of spudwells, internal and external (Figure 1), developed by CEL to provide the NL P-Series pontoon system with an elevating capability, performed satsifactorily. The internal spudwells allowed the pierhead sections to be joined side by side, and the piles could be cut off close to the deck [within 10 inches (25.40 cm) or flush] for truck traffic clearance. In the causeway-to-pile connection, the steel gussets restricted cutting the piles to about 10 inches (25.4 cm) above the deck or flush with the deck if the gussets were welded under the pontoon deck.

Figure 1. Causeway test section with internal and external spudwells.

The external spudwells allowed two-way traffic on the roadway sections from the beach to the pierhead without having to cut off the piling. The external spudwells also performed very well in positioning and holding the piling for the fender system at the pierhead. Pile guides were tested when installing and driving the fender piling. These steel plate guides were slipped into the external spudwell hole before the fender piles were inserted. With the guides installed, the piles were held in a more vertical alignment during and after driving. The guides were removed after the piles were driven. This vertical alignment of the pile was considered desirable for the fender system operation.

1.2.2 Elevated Causeway Installation and Retrieval

The Phase I test conducted in June-July 1975 used the same lift system and equipment to elevate the pontoon sections as in the Phase II test. However, only four pontoon sections and one fender string were involved (Figure 2).

The wave environment during Phase I was much more severe than that encountered in Phase II, with the maximum height of breakers in excess of 8 feet (2.4 m). Pile handling and driving and causeway elevation were conducted during the Phase I test (Figure 3). About 5 days were involved in installing the four sections. The pier installation included: beaching of the sections, driving the piles, elevating or raising the sections to proper height above the water with the lift system, connecting the chain and turnbuckles to hold padeyes, and welding gussets between the piles and the spudwells (Figure 4). With the training gained during the pier installation, it was estimated that the crew could install the four sections in one 12-hour day. The time to lower and remove the sections from the beach was 2 days. The results of this test demonstrated the feasibility of the components to perform the required concept functions, and it was recommended that the Phase II test be conducted.

During the Phase II test, the installation of the elevated causeway sections involved establishing procedures and training the military crew during most of the elevating period (Figure 5). When rough water [6-1/2-foot (2-m) breakers] was encountered, the pile setting and driving was slowed or stopped for safety reasons. An example of a planned delay in the operation procedures was the stopping of the pile-driving crew (see Appendix A, 14 November, 1330) to await the elevating crew's disconnection of the end connections. This was not a normal delay as the sections can be connected or separated while piles are being driven or have been driven in other sections. (Note, however, that having a 10-man crew inactive for several hours does not delay the elevating operation as the pile driving proceeds more rapidly than the elevating.) The installation procedure required 13 days (12 November to 26 November, excluding 15 and 16 November) for nine sections (Section No. 5 under the turntable was removed). When the planned delays and other nonoperational

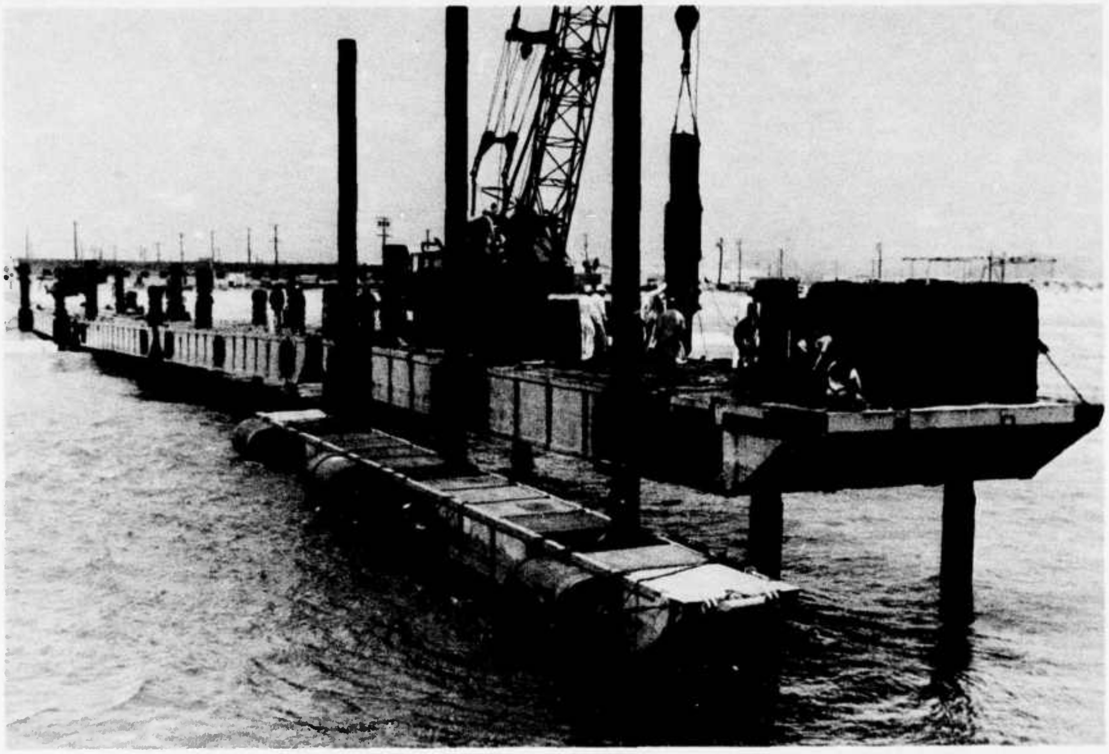


Figure 2. Four-section elevated pier, Phase I tests.

periods are accounted for, the actual time to install the nine sections, including the fender system, was about 66 hours, or 7.3 hours per section. During the latter part of the operation, it was estimated that training had improved crew operations to the level that sections could be installed at a rate of 3 to 4 hours per section.

The average depth for driving the piles was 10 feet (3 m) into the sand bottom. A pier settlement of about 0.8 inch (2 cm) was measured during the elevating and container-handling tests. A check of settlement just prior to retrieving the pier on 5 January 1976 showed an increase to about 1.5 inches (4 cm). Pier settlement was fairly uniform overall (Figure 6).

Six days (5 to 10 January 1976) were involved in retrieval, i.e., lowering the nine sections (including removing the fender system) and pulling the piling. Five sections of the approach causeway were lowered simultaneously while end-connected; this procedure took about 7 hours. Forty-one hours were spent during the 6 days to lower the nine sections, but actual working time was about 25 hours.

1.2.3 Side Connectors

No side-connector installations were used during the Phase I operation. Side-connector units were installed for making the pierhead sections into a two-by-two array to provide a continuous platform 42 feet (12.8 m) wide. During Phase II, equipment was transported to the landing site aboard the side-connected sections. The side connectors were disconnected before elevation, then reconnected after the sections were in their final elevated position. Although some minor problems were experienced in the connection procedures, the functional performance of the side connectors was good.

1.2.4 Deck Reinforcement

The 3x12 timber reinforcement for the pontoon

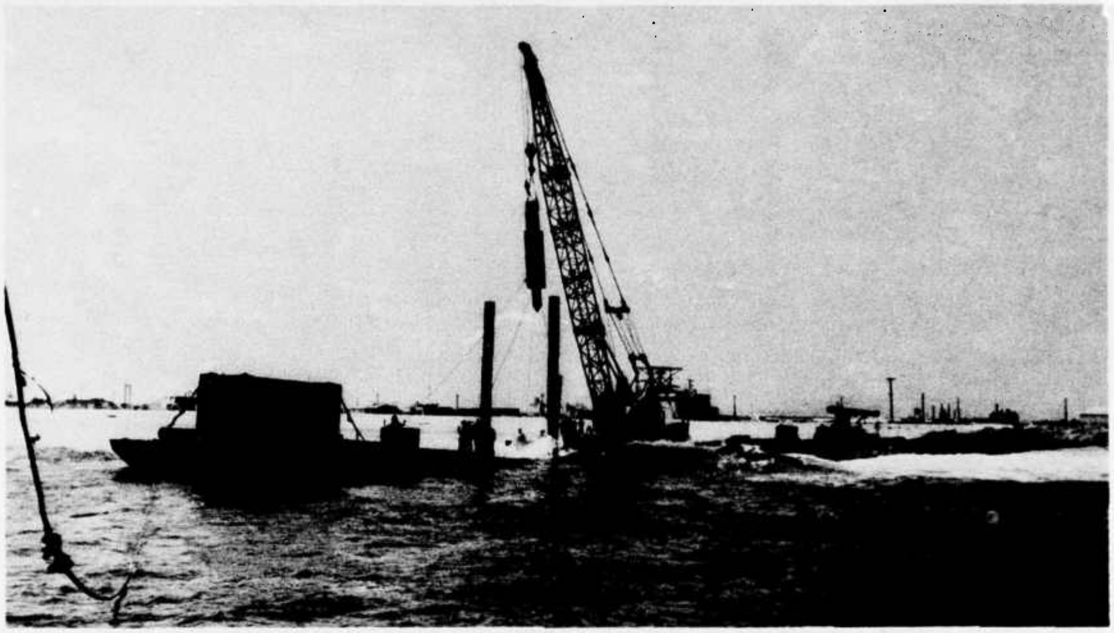


Figure 3. Placing and driving pile during 6-foot (1.8-m) wave.

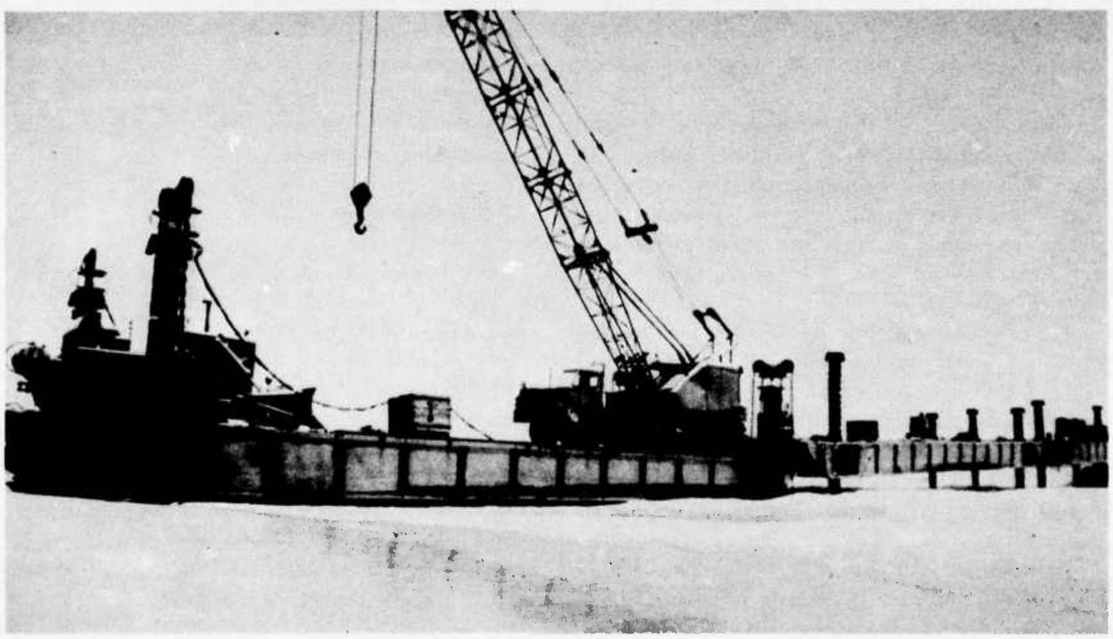


Figure 4. Elevating section with crane and tractor on board.

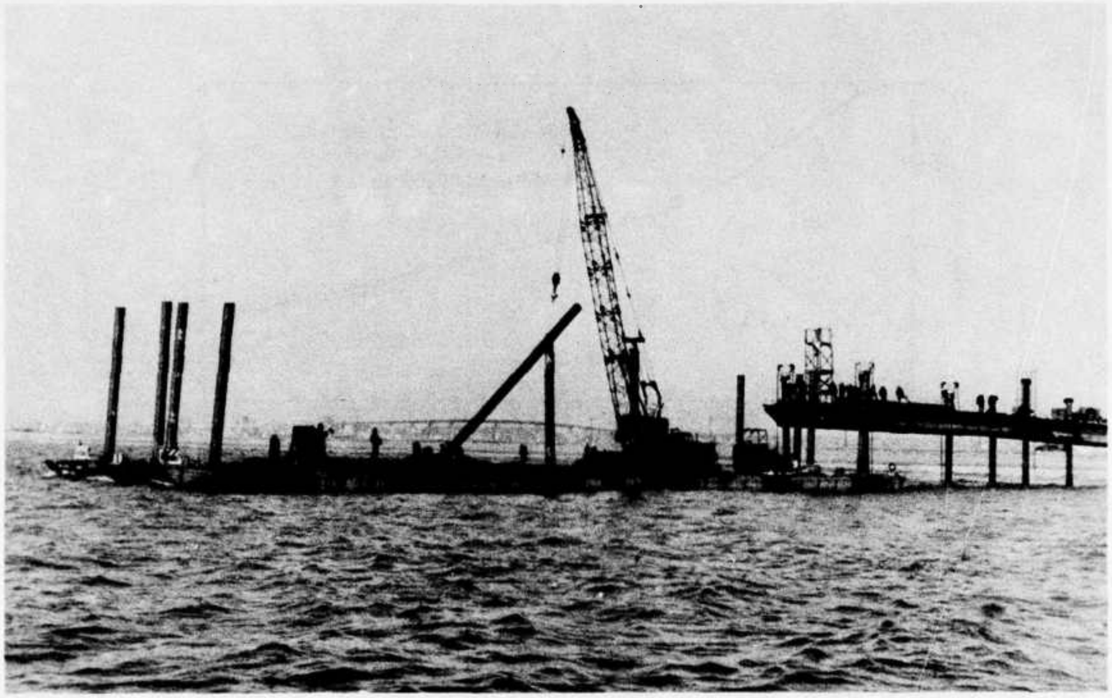


Figure 5. Hydraulic jacks lifting causeway section while piles are being placed in following sections.

deck performed satisfactorily for the wheeled vehicles during Phase I and Phase II operations. Steel cleats on the tractors shattered some timbers and tore loose some of the steel restraining straps. Also, the reinforcement needs to be widened to provide for continuous two-way truck traffic on the elevated roadway from beach to pierhead. The pontoon deck is designed to support an H20 highway loading, i.e., a 32,000-pound (14,500-kg) axle load and a 75-psi (517-kPa) wheel (footprint) pressure. The pontoon angles, which run longitudinally on the sections, increase the load-carrying capability significantly if the axle/wheel loads can be concentrated over the angles. Vehicles, such as the rubber-tired crane, weighing 74 tons (67 Mg), and the top-lift loader with a 20-ton (18-Mg) container, weighing 62 tons (56 Mg), have been driven over the 3x12 timbers. The crane applied a maximum load to the pontoon deck of 28,000 pounds (12,700 kg) per dual wheel [footprint pressure of 90 psi (620 kPa)], and the top-lift loader with the 20-ton (18-Mg) container applied a load of 52,800 pounds (23,950 kg) per dual wheel [footprint pressure of 100 psi (689 kPa)].

1.2.5 Beach Ramp and Matting

The 30-foot (9-m) steel beach transition ramp was used only in the Phase II test. The ramp was installed and removed by the 35-ton (32-Mg) capacity crane. The pin attachment to the existing end-connector padeyes worked satisfactorily, as did the ramp during the pier elevation and container-handling operation. The M8A1 steel beach matting performed very well in supporting both the container trucks and cranes across the sand area. A six-man crew installed 24 x 150 feet (7 x 46 m) of the matting at the end of the beach ramp. A rough-terrain fork truck was required to move the bundles of matting into position. It was found that the matting could not be reused after the operation, because the pin joints holding the sections together were bent by the traffic. So even though the steel plates are still useable, the sections cannot be disassembled, stored, and reassembled at another site.

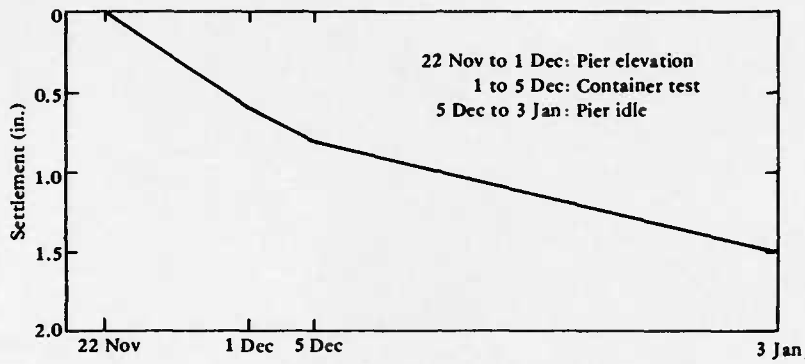


Figure 6. Settlement of elevated pier.

1.2.6 Fender System

One 1x15 pontoon string [7 x 90 feet (2 x 27 m)] with four foam fenders was installed at the Phase I test pier. Impact tests were conducted, and the instruments recorded wave-loading forces up to 44,000 pounds (196,000 N) on one fender piling. The severe surf condition caused some damage to the foam fenders, but they were still operational. The fender system worked well, and no major difficulties were encountered in installation, operation, or removal. The system was recommended for the Phase II test.

Two fender units were brought end-connected [7 x 180 feet (2 x 55 m)] to the elevated pier by a pontoon tug and six piles were driven in the fender spudwells in about 2 hours. The calm sea conditions that prevailed during the Phase II operation limited the evaluation of the fender system to protect the lighters. Therefore, specific impact tests were conducted using a pontoon warping tug. The tug struck one fender string (one Seaward foam fender) head-on at velocities of about 5 knots. Two piles, 20 inches in diameter (508 mm) and 3/8 inch (10 mm) in wall thickness, were damaged during the tests. Maximum impact load measured at the pierhead was in excess of 70,000 pounds (32 Mg). The fender system was still operable after the impact tests.

1.2.7 Lighters

The three types of lighters used in the container operations, i.e., the three-section causeway ferry, LCU 1652 (class 1610) and LCM-8, operated without difficulty at the pierhead with the calm water conditions. The David Taylor Naval Ship Research and Development Center (DTNSRDC) obtained craft motion [1] and wave measurements during the tests, but, because of the calm water, very small motions were indicated for the lighters. The maximum pitch recorded was 2.4 degrees on the LCM-8 and 1.5 degrees for both the ferry and LCU. Extremely small translational accelerations were obtained on all lighters during the tests. The wave height spectra developed from the data indicated that most of the seaway energy was from a predominant swell component with a period of about 14 seconds.

1.2.8 Trucks, Turntable, and Crane

The turntable was used 148 times to rotate the truck/trailers. Average time per truck/trailer (tractor front wheels on ramp to trailer rear wheels off ramp) for the first third of the operation was 87 seconds, 74 seconds for the second third, and 53 seconds for the last third. The fastest time was 37 seconds. Time for the truck to move from the crane area to the beach

was 2 minutes. Average time for the crane to move containers from a lighter to a trailer was: causeway ferry, 3.0 minutes; LCU and LCM-8, 3.5 minutes. Thus, the average time to move containers from a lighter to the beach was 5.0 to 5.5 minutes. Crane cycle times of 3 minutes per container were recorded so that, with a proper truck/turntable pattern (i.e., always having a trailer waiting for the crane), the number of containers per hour can be increased to 20.*

The 90-ton (82-Mg) capacity crane was satisfactory during these tests, but it was operating at about its maximum lift/reach capability when handling the 20-ton (18-Mg) container at a 40-foot (12-m) reach. A 140-ton (127-Mg) capacity crane would be more reliable when higher wave conditions exist.

The planned truck/turntable pattern for these tests was revised because of the loss of the turntable section. This required relocating the turntable on a pierhead section, thus resulting in the loss of space by having a truck waiting to move into the crane-loading area.

The air-bearing transporter used to unstuff the container at the beach was able to extract the 20-ton (18-Mg) load in 20 to 30 seconds. Two men operated the system and restored the unused supplies into the container without difficulty.

1.2.9 Lo/Ro Operation

In the Lo/Ro concept, containers are delivered deck-loaded on a causeway ferry; the ferry is beached, and the containers are off-loaded with commercial container handlers. No Lo/Ro operations were conducted during the Phase I tests. Two tests were conducted (20 November and 4 December 1975) during the Phase II operations. The first test involved building a sand ramp level with the causeway deck and testing both steel mat and Mo-Mat to support the top-lift loader (TLL) on the beach. The sand ramp was built level with the ferry deck initially to assure that the TLL would not high center on the ramp. A second test was planned to test the TLL/ramp clearances.

Total elapsed time for the first test was from 1046 to 1611 hours to unload 12 containers and test the matting. A five-section ferry, propelled by one pontoon warping tug, was loaded with 12 containers on the three shoreward sections (four containers per section). The other two sections were used to keep the tug out of the breaking surf, but they would have carried containers in a normal operation. The average time for the TLL to approach the causeway, pick up a container, and then leave the causeway was 2 minutes. This average time did not include the travel time to the storage area, which was about 400 feet (122 m) away. The time to travel to and from the storage area was 3 minutes.

The Mo-Mat would not support the TLL on the soft beach sand and had to be replaced with steel mat. The M8A1 steel mat was satisfactory, although it did curl slightly under the TLL wheel loads.

Prior to the second test, the landing site was back-bladed using a tractor (about 10 minutes to level sand slightly), an empty three-section causeway was beached and pulled higher onto the beach with tractors (8 minutes), and the ramps were dropped and steel matting was pulled to the end of the causeway (15 minutes). Time from beaching to backloading six containers was 55 minutes, which includes travel to and from the storage area. Time to off-load six containers to the storage area was 30 minutes. No problem was encountered in driving the TLL over the ramp and onto the ferry.

1.2.10 Environmental Data

During the Phase I test period, 16 June to 16 July 1975, two tropical storms occurred off the coast of Mexico that generated heavy swell at the test site at Point Mugu. On 7 and 8 July, breakers in excess of 8 feet (2.5 m) were noted. The breakers approached the pier during the test at angles of 5 to 30 degrees, and, on occasions, swells struck the pier from two directions simultaneously. The breakers imparted more severe motions to the crane boom, piling, and pile driver than occurred during Phase II. The shore length of the four-section pier, which placed all

*Average container-handling rates per hour do not include time lost between arrival of lighters (the tie-up of the lighter to the pierhead is included in the overall times listed); therefore, the rate per hour could be less than 20 containers if a lighter were not waiting for the crane.

sections within the breaker area, also increased the motion problem and working hazard. Waves were frequently breaking across the floating sections during the elevating period.

Swells and breakers were relatively calm during the Phase II operation. Breakers up to 5.5 feet (1.7 m) were observed during 1 to 2 days of pier elevation. Surf conditions during the container-handling operations, 1 to 5 December (including Lo/Ro), were calm and presented no problem either to the lighters during mooring or container handling.*

1.2.11 Human Factors

The Naval Electronics Laboratory Center (NELC), San Diego, conducted a human engineering study of the elevated causeway installation/retrieval and container-transfer operations. The emphasis of this study was placed on improving man and equipment interactions and in developing personnel requirements. The tasks performed by the crews were identified by direct observation and review of video tape recordings taken during the Coronado tests. An analysis was then made to identify man/equipment problem areas and possible solutions. Attention was given to personnel numbers, skill levels, and their utilization. Personnel hazards were also identified, and suggested methods of correcting them are presented.

Areas for improvements are suggested in the jack rigging operation, particularly for gimbal assembly and pile cap handling. Other items discussed include alternate methods of securing piles to the causeway sections to reduce causeway elevating time, personnel, and equipment requirements; prepositioning of piles in the spudwells for transport to the beach site along with alternate methods of pile attachment; and improved crew allocations. These human factor items are covered in detail, along with recommendations and proposed future efforts, in Volume II; a summary of the findings is given in Appendix C.

*See Appendix B for detailed information on environmental conditions at both test sites.

SECTION 2

INTRODUCTION

2.1 SCOPE

The advanced development tests for the elevated causeway were performed to evaluate system hardware, using an adequate number of pontoon sections, existing military lighters and trucks, and 8 x 8 x 20-foot (2.4 x 2.4 x 6-m) commercial containers. The equipment tested included four specially assembled NL pontoon pierhead sections with internal spudwells, five existing pontoon sections equipped with external spudwells, two types of plastic foam fender systems, three types of Navy lighters, one type of Marine Corps tractor/trailer, a turntable, and two types of commercial container handlers. In addition, other selected hardware items were evaluated during the operation. Timing data were taken at all pertinent points of the operation; however, this information was considered to be secondary to determining any operational limitations, proper procedures, and problems requiring further development efforts.

2.2 BACKGROUND

DOD planning for the logistics support to sustain major contingency operations, including amphibious assault operations and Logistics-Over-The-Shore (LOTS) evolutions, relies extensively on the utilization of U.S. Flag commercial shipping. Since the mid-1960s commercial shipping has been steadily shifting towards containerships, Roll-On/Roll-Off/(RO/RO) ships, and bargeships (e.g., LASH, SEABEE). By 1985 as much as 85% of U.S. Flag sealift capacity may be in container-capable ships – mainly non-self-sustaining (NSS) containerships. Such ships cannot operate without extensive port facilities.

Amphibious assault and/or LOTS operations are usually conducted over undeveloped beaches, and expeditious response times preclude conventional port development. The handling of containers in this environment presents a serious problem. This problem is addressed in the overall DOD Over-the-Shore Discharge of Cargo (OSDOC) efforts, which involve developments by the Army, Navy, and Marine Corps. Guiding policy is documented in the "DOD Project Master Plan for Surface Container Supported Distribution System" and the OASD I&L system definition paper "Over-the-Shore Discharge of Cargo (OSDOC) System."

In response to the DOD Master Plan, Navy Operational Requirement (OR-YSL03) has been prepared for an integrated Container Off-Loading and Transfer System (COTS) for discharging container-capable ships in the absence of port facilities. The COTS Navy Development Concept (NDCP) No. YSL03 was promulgated July 1975, and the Navy Material Command was tasked with development. The Naval Facilities Engineering Command has been assigned Principal Development Activity (PDA) with the Naval Sea Systems Command assisting.

The COTS advanced development program includes the ship unloading subsystem, the ship-to-shore subsystem and common system elements. The ship unloading subsystem includes: (a) the development of Temporary Container Discharge Facilities (TCDF) employing merchant ships and/or barges with add-on cranes and support equipment to off-load non-self-sustaining containerships alongside; (b) the development of Crane on Deck (COD) techniques and equipment for direct placement of cranes on the decks of NSS containerships to render them self-sustaining in an expedient manner; (c) the development of equipment and techniques to off-load Ro/Ro ships offshore; and (d) the development of interface equipment and techniques to enable ship discharge by helicopters (either existing or projected in other development programs).

The ship-to-shore subsystem includes the development of elevated causeways to allow cargo handling over the surfline and development of self-propelled causeways to transport cargo from ships to the shoreside interface.

The commonality subsystem includes: (a) the development of wave-attenuating Tethered Float Breakwaters (TFB) to provide protection to COTS operating elements; (b) the development of special cranes and/or crane systems to compensate for

container motion experienced during afloat handling; (c) the development of transportability interface items to enable transport of essential outsized COTS equipment on merchant ships – particularly barge-ships; and (d) the development of system integration components, such as moorings, fendering, communications, and services.

The Civil Engineering Laboratory (CEL) was designated by the Naval Facilities Engineering Command (NAVFAC) as the responsible laboratory for the ship-to-shore subsystem. This report covers only that portion of the ship-to-shore subsystem related to the elevated causeway components and associated container-handling operations.

The parameters used by CEL to develop and evaluate the elevated causeway system are:

Configuration Objectives

- Capable of being transported by LST and commercial carriers, including bargeships
- Provide for lighterage operation/cargo handling and transfer beyond the surf zone
- Capable of being installed in breakers/swells up to 7 feet (2.1 m); survive in swells up to 15 feet (4.6 m)
- Capable of being installed at an average rate of 2 to 4 hours per section
- Capable of being elevated 15 feet (4.6 m) above mean low water [allow for 8-foot (2.4-m) tide and 7-foot (2.1-m) swell] in water depths of 10 to 20 feet (3.0 to 6.0 m) at the pierhead
- Provide fender system for pier/lighterage interface and line-handling capability for lighterage
- Provide system capability for truck turnaround on the causeway and a means for expanding the elevated causeway installations

Performance Goals

- Install elevated causeway pier from beach to a point offshore suitable for lighterage operations, which are
  - Causeway/container crane operations: handle 20-foot (6.0-m) [22-ton (2.0-Mg)] up to and including 40-foot (12.2-m) [35-ton (32-Mg)] containers at 40-foot (12-m) radius
  - Container transfer rate: 10 to 12 containers per hour from lighterage to shore; use multiple components to meet greater demands
- Use existing Navy assets augmented by commercial hardware to the maximum extent practical
- Be compatible with cargo from existing containerships and other container-capable ships, such as RO/RO ships, bargeships, and other cargo ships
- Provide limited container-handling capability (Lo/Ro and Ro/Ro at an early time frame)
- Introduce elevated causeway components into Fleet by end of FY 78

Operational Criteria

- Sustained operations in sea state 3 [significant wave height, 5 feet (1.5 m)] with 30-knot (15.4-m/s) winds, 4-knot (2.0-m/s) current
- 20-foot (6-m) water depth at pierhead
- 7-foot (2-m) surf and 8-foot (2.4-m) tide
- Survive in sea state 6 with 75-knot (38.6-m/s) winds, 4-knot (2.0-m/s) currents
- Survive hurricane forces when given 24-hour warning, and operational within 48 hours following the storm

CEL planned the elevated causeway tests in two phases. The Phase I tests, which were conducted by CEL at Point Mugu, California, were designed [2] to investigate operational and structural capabilities of the NL elevated causeway and to develop operational procedures. No container-handling tests were included in this phase. The Phase I tests [3] were conducted from 16 June to 16 July 1975.

The Phase II tests were designed to be conducted by military operators, i.e., PHIBCB-ONE and ACU-ONE, Coronado, California, to determine operational limitations and any further development requirements. Container-handling operations were included in these tests. The pier was elevated by PHIBCB-ONE on Silver Strand Beach, Green Beach Two at 32°39'08" latitude, 117°09'25" longitude, beginning 12 November 1975 and finishing on 26

November 1975. A survey of the landing site showed a beach gradient of about 1:30 and a water depth of 20 feet (6 m) at zero tide 600 feet (183 m) offshore. Container-handling operations began on 2 December and were completed on 5 December 1975. The container-handling crane was positioned on the pierhead on 1 December. The pier was left elevated until 5 January 1976 to check for piling settlement and to provide an opportunity for the pier to encounter rough seas and was disassembled from 5 January to 10 January 1976. Movies [4, 5] have been prepared covering both Phase I and Phase II tests.

2.3 REPORT COVERAGE

The documentation of the Phase I and Phase II tests consists of this Summary Report, Volume I, and four other volumes; the other volumes cover the following.

2.3.1 Volume II

This volume reports on the elevating mechanism or lift system and alternative lift procedures and associated equipments. Included are description of elevated causeway, pier installation and retrieval (including pro and con of elevating from shore out or offshore in), pile hammer and driving, beach gradients and surveys, ladders and scaffolding, and discussion of multisection lift. A human engineering study was made of both the elevated causeway system hardware and the associated operational procedures. This study was conducted by the Human Factors Technical Division, Naval Electronics Laboratory Center, San Diego, and is reported in this volume.

2.3.2 Volume III

This volume describes the pontoon equipment (including section assembly, internal and external spudwells), structural reinforcements required for the container-handling crane, side connectors, and results of structural behavior tests.

2.3.3 Volume IV

This volume contains descriptions of the fender system, installation procedures, and lighterage impact tests. The lighterage motions recorded during the container-handling operation are also given.

2.3.4 Volume V

This volume details container handling, i.e., container transfer rates, container crane, containers, lighters, Marine Corps truck/trailers, pontoon deck reinforcement, turntable, beach ramp and matting, and air-bearing transporter. An alternate method of ship-to-shore container transfer, i.e., the load-on/roll-off causeway ferry system (Lo/Ro), using a commercial top-lift loader was tested and is described in this volume.

SECTION 3

ELEVATED CAUSEWAY SYSTEM

3.1 OVERALL SYSTEM

The elevated causeway system design provides for an interface between lighterage and the beach by bridging the surf zone. The elevated access terminates at the offshore end in a pierhead that supports the cargo unloading functions. The major developments include an elevating capability for the existing NL pontoon causeway, a crane installation at the pierhead for off-loading from lighterage moored alongside the causeway, fendering to interface the elevated pierhead and the lighters, turnaround components to handle truck/trailers on the causeway, and a two-way traffic access from the pierhead to the beach.

The system is based on the 3x15 pontoon section, 21-feet wide by 90 feet long (6.4 m by 27.4 m), which is elemental to the Amphibious Construction Battalions. To convert the floating 3x15 pontoon structure to the elevating mode requires the addition of spudwells, either external or internal. The internal spudwells are used in the pierhead where sections are side by side, and the external ones are used in the connecting causeway.

Basically, the sequence of installation is:

(1) Beach all sections connected in the floating mode

(2) Place and drive piling

(3) Install the lift jacks [6]

(4) Disconnect the end-to-end (or side-by-side) connection on the section(s) to be elevated

(5) Elevate the section(s)

(6) Secure the elevated section to the piles (temporary)

(7) Remove the jacks

(8) Move on to next section and repeat steps 3 through 7

(9) Remake the connection when adjacent sections are elevated

(10) Install fender components after pierhead is complete

After the work is underway, many of the functions are performed concurrently, as is the task of making permanent pile-to-causeway connections.

The advanced development tests at Coronado, California, were conducted with the following structure: four pierhead sections (No. 1 through 4), five approach sections (No. 6 through 10), and the turntable section (No. 5) located seaward of the pierhead. Before the turntable section could be elevated, it was damaged during severe seas and could not be used. Consequently, the turntable was relocated to pierhead Section No. 1.

The modularity of the elevated system allows the field commander flexibility in sizing out the pierhead and approach. As a minimum, the four special pierhead sections should be used to establish the offshore container-handling facility. The 2x2 section pierhead can be expanded in both length and width dimensions to meet requirements. The length of the approach causeways should be selected to bridge the surf and locate the pierhead in sufficient water depth for anticipated lighterage.

The construction/installation equipment tested were similar for both the Phase I and II tests, with container-handling components added for the Phase II tests. The equipment included new items designed to facilitate elevating the NL pontoon sections and some existing military and commercial hardware (see Table 1).

3.2 COMPONENTS

3.2.1 Elevating System

The elevating system [6], which is packaged in one 8 x 8 x 20-foot container, consists of five hydraulic chain jacks (includes one spare jack), gimbals, stud-link chain, a hydraulic power unit, connecting hydraulic hoses, and miscellaneous

Table 1. Construction and Installation Equipment

The Elevated Causeway Provides	Equipment/Hardware Evaluated
A pier roadway from the beach for truck/trailers; composed of 3x15 NL pontoon sections with external spudwells; raised above the water and extending from the beach to a pierhead (beyond the breaking waves); sufficient water depth to accommodate lighters.	Lift system[a] (hydraulic jacks, power unit, gimbals, pipe caps, accessories); spudwells, piling, pile hammer; 35-ton (32-Mg) capacity mobile crane; 5-ton (4.5-Mg) capacity hydraulic crane.
A platform (pierhead); consists of 3x15 NL pontoon sections with internal spudwells; supports a container-handling crane; supplies a roadway for the truck/trailers to transport the containers; contains an area for the turntable for the truck turnaround.	90-ton (82-Mg) rated capacity mobile crane;[b] Marine Corps M52/M127 truck/trailers; turntable, side connectors; beach ramp and beach surfacing.
Attachment/installation points for the lighterage fender components.	Internal/external spudwells; 1x15 pontoon strings; piling; pile guides.[c]
Components for mooring the lighters to the pier.	Double bitts, 7-inch (178-mm) double-braid polyester line.[b]

[a]Detailed in Volume II.

[b]Detailed in Volume V.

[c]Detailed in Volume III and IV.

hardware. The two types of spudwells, internal and external, which were developed by CEL, provide alternative methods for raising the NL pontoon sections in conjunction with the jack system. A DE-30 diesel-driven pile hammer was used to drive the steel piles. A P&H Model 935 rubber-tired truck crane was used to handle the pile hammer and piling. A 5-ton (4.5-Mg) capacity hydraulic crane was used in conjunction with the 35-ton (32-Mg) capacity crane to move jacks and accessory gear on the causeway.

3.2.2 NL Pontoon Sections

Four 3x15 pontoon sections were assembled at CEL for the pierhead (Figure 7). The internal spudwells used in these sections provide for a clear outside edge and permit sections to be positioned side by side. Four spudwells were assembled in each section, except for the two sections which would support the container-handling crane. Two additional internal spudwells were added to each of these sections. Also, the exterior pontoon angles adjacent to the crane/container operation were reinforced to resist the greater moments and shears introduced into the structure by the crane lifting 20-ton (18-Mg) containers from the lighters. The four sections, along with the crane, the pile hammer, and accessory gear, were shipped to Coronado by LSD-31 *Point Defiance* on 29 October 1975 (Figure 8).

Six existing 3x15 NL pontoon sections were obtained from Amphibious Construction Battalion ONE (PHIBCB-ONE), Coronado, and the sections were modified by adding AP7 mounting plates for external spudwells. These AP7 plates were installed by the Public Works Center (PWC), U. S. Naval Base, San Diego, California. After the sections were modified, PWC installed the external spudwells and load-tested the sections statically with 85-ton (77-Mg) weights.

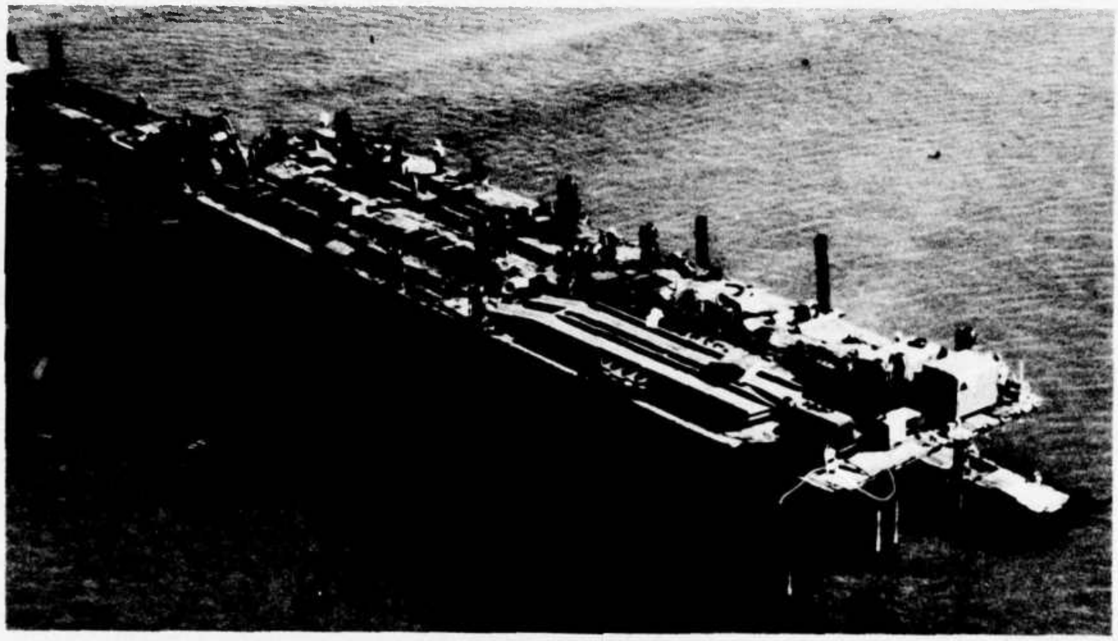


Figure 7. Elevated causeway pierhead.

Figure 8. Loading elevated causeway components into LSD.

3.2.3 Side Connectors

A side-connector device was fabricated to join the sections side by side and to strengthen the pierhead. This device is composed of a probe mounted in one causeway section and a receiver fitted into an adjacent section. The probe and receiver fit within the 9-inch (228-mm) space between the pontoons of each section. A hydraulic ram is used to move the probe to engage a corresponding receiver in an adjacent section. The side-connecting device resists longitudinal and vertical shear forces in addition to the lateral forces that tend to pull the sections apart. Two side connectors are used in each pair of sections to be joined side by side.

3.2.4 Beach Ramp and Surfacing

A 30-foot (9-m) long, two-piece steel ramp provides a roadway from the elevated shore section to the beach (Figure 9). Each ramp piece weighs 9 tons (8 Mg) and attaches to the open padeyes of the NL pontoon end connection. The ramp is capable of supporting the 148,000-pound (67-Mg) container-handling crane. Steel matting (M8A1) was provided as a beach surfacing at the end of the causeway (Figure 10).

3.2.5 Fender System

Two 1x15 NL pontoon strings were assembled with three internal spudwells (Figure 11). Two types of plastic fenders (or cushions) – Ocean Systems and Seaward International – were tested. The nominal dimensions of the Seaward cushions are a 4-foot (1.2-m) diameter by a 7.4-foot (2.25-m) length; six cushions were installed on one of the 1x15 sections. The Ocean Systems cushions are 4 feet (1.2 m) in diameter by 10 feet (3 m) in length; three of these cushions with one Seaward cushion were installed on the second 1x15 section.

Steel piles, 20 inches (508 mm) in diameter by 3/8 inch (10 mm) in wall thickness, were driven through the spudwells to restrain the fender strings and to provide resistance to the lateral impact of the lighters. Pile guides were used in several external spudwells attached to the pierhead to hold the piling in a vertical alignment. These guides consisted of two pieces of 1/2-inch (12.7-mm) thick steel plate, 5 feet (1.5 m) long, formed to fit between the pile and the spudwell. The two 1x15 strings with plastic cushions were transferred from CEL to Coronado by LSD 31 on 29 October 1975 (Figure 12).

3.2.6 Crane and Containers

A 90-ton (82-Mg) rated capacity, rubber-tired truck-mounted commercial crane, P&H Model 8100 (Figure 13), was leased from Enniss Company, El Cajon, California, for the tests. Equipped with a 70-foot (21-m) boom, the crane has a hook capacity of 26 tons (24 Mg) at a radius of 34 feet (10.4 m). The crane is approximately 33 feet (10 m) long by 11 feet (3.3 m) wide by 13 feet (4 m) high and has an operational weight of 148,000 pounds (67 Mg) [counterweight, 26,000 pounds (12 Mg)]. Lease charges for the crane, including an operator and helper, was $100 per hour. Transport and set-up charges were $1,000. The total cost for the time the crane was on site from 1 to 5 December was $4,000.

Two types of container-handling gear were used – a 3,000-pound (1.4-Mg) manual spreader bar (Figure 14) and wire rope slings equipped with bulb hooks (Figure 15) to lock into the container corner pockets. Eighteen 8 x 8 x 20-foot (2.4 x 2.4 x 6-m) containers, weighing 4,400 pounds (2 Mg) each, were leased from the Pacific Far East Line, San Diego, for $3,500 per month. Two of the containers were loaded to 20 tons (18 Mg) with concrete weights. The weights were fabricated by the Public Works Center, Naval Base, San Diego.

Container handlers, mobile truck cranes, and truck/trailers create tire print pressures up to 130 psi (896 kPa). This pressure exceeds the allowable stress of about 75 psi (517 kPa) of the pontoon deck plate; thus, a suitable reinforcement is required. The pontoon causeway deck was reinforced with 3 x 12 timbers to distribute the vehicles' weights while transiting the causeway and on the pierhead. These timbers were secured to the deck with 3/16 x 2-inch (95 x 50-mm) steel straps placed across the timbers and welded to the deck. The AP1 pontoon assembly plates were not level with the timber roadway; therefore, they were covered by plywood sections. The plywood was held by steel straps welded across the A6 bolt heads (Figure 16).

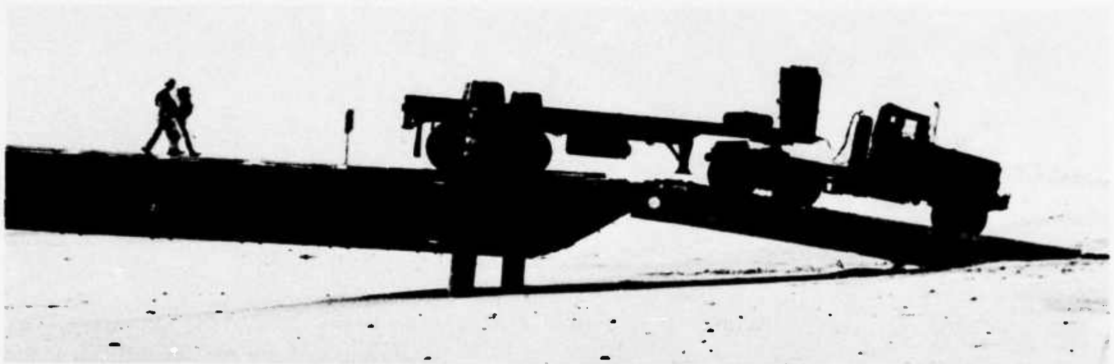


Figure 9. Ramp from beach to elevated causeway.

Figure 10. Steel mat, M8A1, used to support container crane and container transporters across beach.

Figure 11. Foam bumpers secured to two 1x15 pontoon strings and restrained by six steel piles.

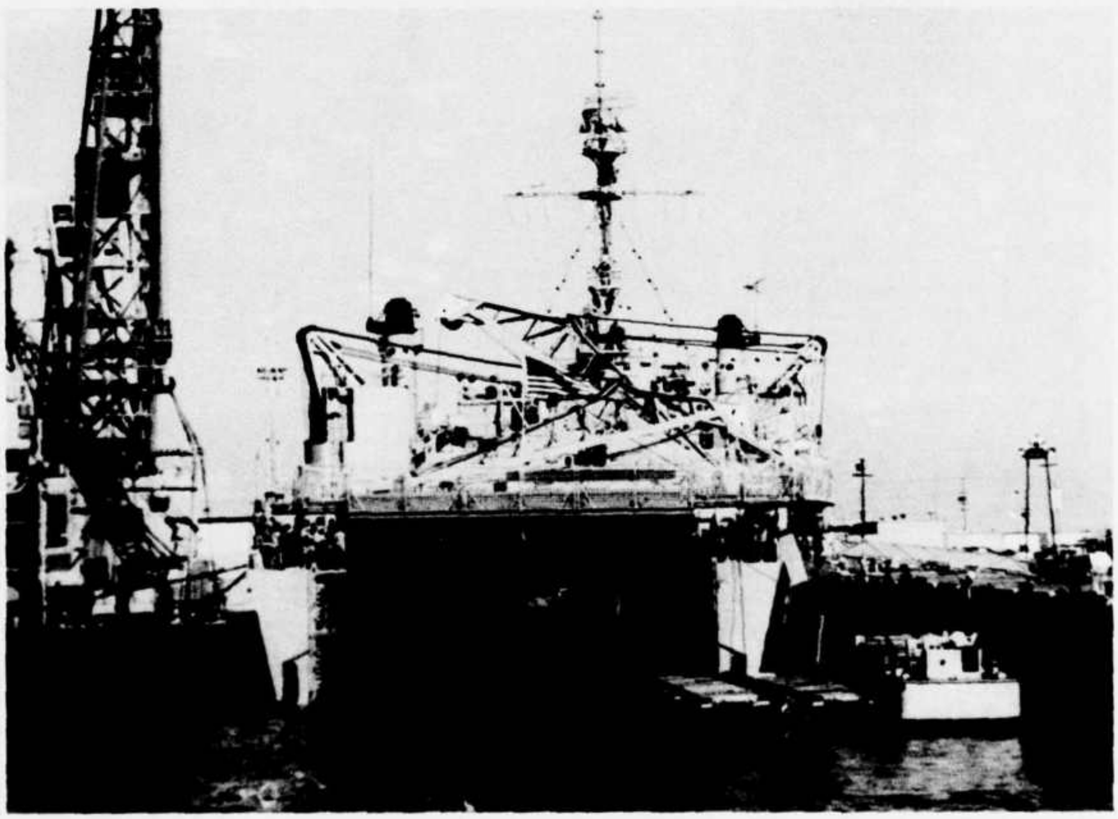


Figure 12. Fender strings being loaded into LSD.

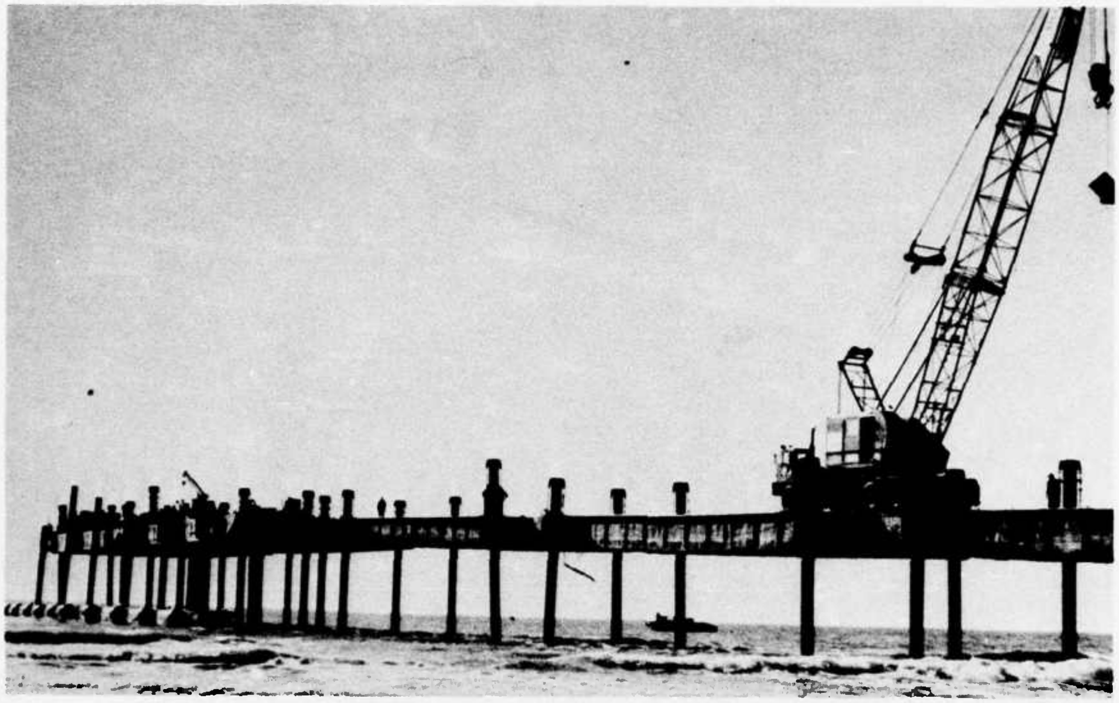


Figure 13. P&H Model 8100, 90-ton (82-Mg) rated capacity truck crane moving to pierhead on causeway.

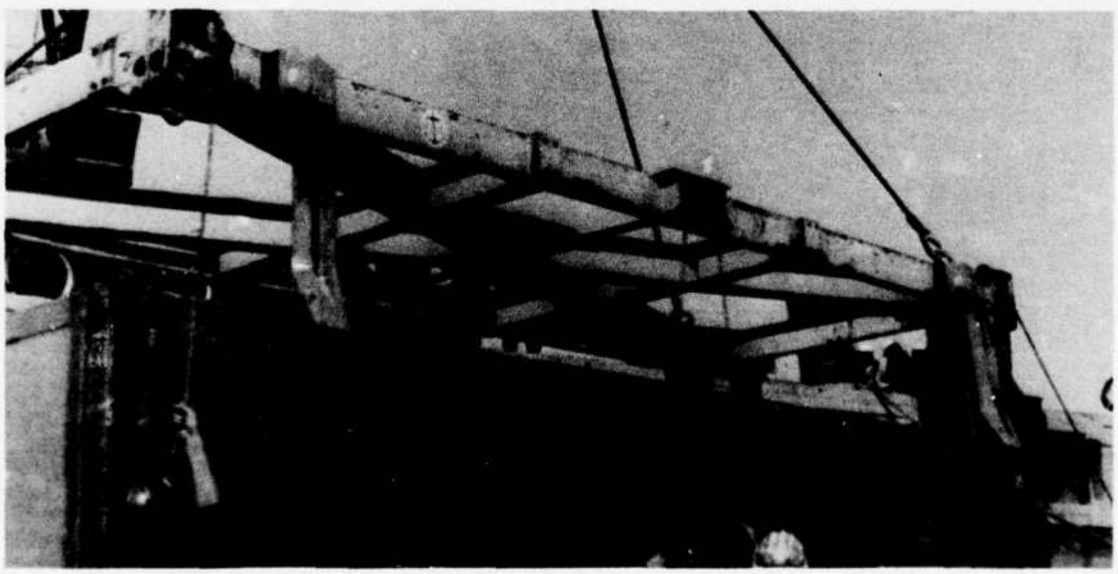


Figure 14. Manual spreader bar.

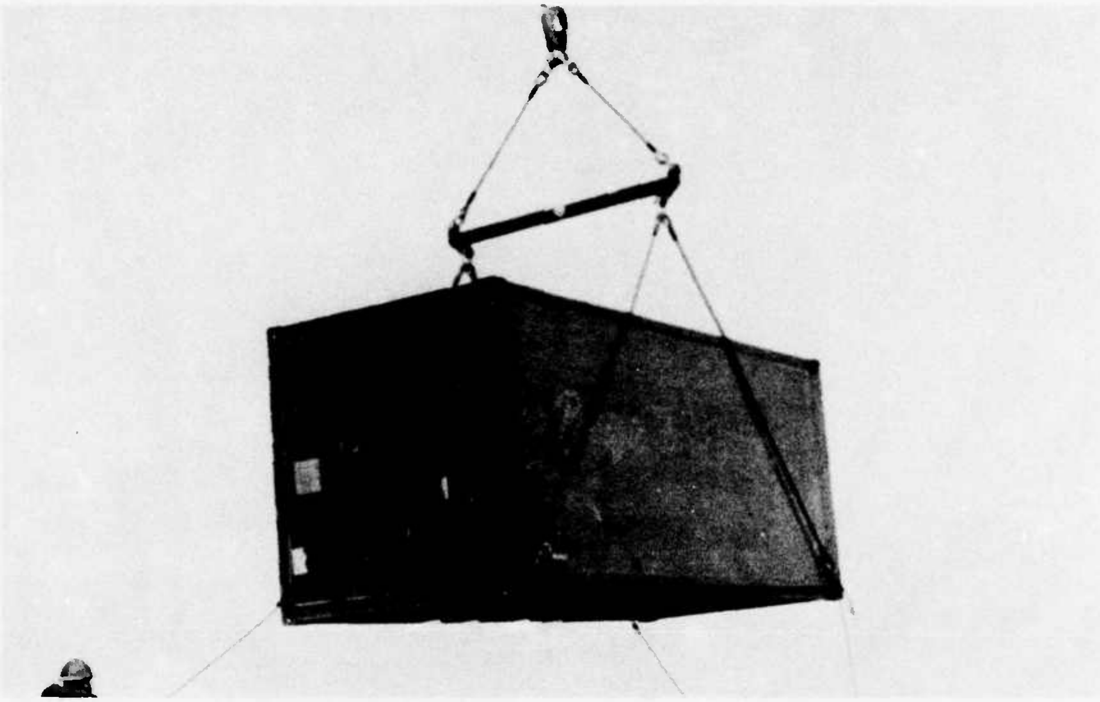


Figure 15. Wire rope slings with bulb hooks.

Figure 16. Pontoon deck reinforcement of 3x12 timbers provides roadway for vehicles.

3.2.7 Lighters

Three types of existing Navy lighters were used to transport the containers to the pierhead, namely, a three-section NL pontoon causeway ferry push-towed by an NL pontoon warping tug (Figure 17), a Class 1610 LCU (Figure 18), and an LCM-8 (Figure 19). Each of the three ferry sections is 21 feet (6.4 m) wide by 90 feet (27.4 m) long with an empty draft of 1.3 feet (0.4 m); displacement of each section is 62.5 tons (56.7 Mg). The warping tug is basically a 3x14 pontoon barge, 23 feet (7.0 m) by 93 feet (28.3 m), with a displacement of 113.5 tons (103 Mg). The LCU is 135 feet (41.2 m) in length with a displacement of 227.5 tons (206.4 Mg), and the LCM 8 displacement and length are 57.5 tons (52 Mg) and 74 feet (22.6 m), respectively.

The causeway ferry carried 12 containers, the LCU, four containers, and the LCM-8, two containers. The lighters were moored to the elevated pier with 7-inch (178-mm) circumference, double-braided, polyester lines attached to 12-inch (305-mm) double bollards welded to the pierhead. Instruments were installed on the three types of lighters to measure their motions while moored to the pierhead. Swell and current data were recorded in the area adjacent to the pier.

3.2.8 Trucks and Turntable

Six Marine Corps truck/trailers, i.e., M52 tractors with M127 trailers (Figure 20) – total length, 42 feet (13 m); weight, 34,000 pounds (15.4 Mg) – were used to haul the containers from the pierhead to the beach. The First Force Service Regiment, First Marine Division, Camp Pendleton, California, furnished the operators and vehicles for the test.

This vehicle requires an area equivalent to about eight causeway sections to turn around at the pierhead area; therefore, a turntable was fabricated to rotate the truck/trailers. The turntable rotates on eight 34-inch (762-mm) diameter air bearings, is 48 feet (14.6 m) long, and has a total weight, including both the upper and lower sections, of 30,000 pounds (13.6 Mg). The system uses a 360-cfm (0.17-m^3/s) air compressor and three men for operation. Cost of the turntable was $30,000.

3.2.9 Pile Hammer

The pile hammer used to drive the 20-inch (508-mm) diameter piles was a diesel-operated DE-30 – weight, 9,075 (4 Mg); rated energy, 22,400 ft-lb (30 kN m); length, 15 feet (4.6 m). This hammer (Figure 21) was obtained from Navy supply at Port Hueneme. A special set of hanging leads were fabricated by CEL to hold the hammer on top of the piling during the driving operation. A smaller hammer, the DE-20 – rated energy, 16,000 ft-lb (21 kN m) – has been used during some early tests and was considered marginal for driving the 20-inch (508-mm) diameter piles into a firm, sand bottom.

3.2.10 Lo/Ro, Top-Lift Loader

One lighterage system that will be available early in the amphibious landing is the pontoon causeway ferry (Figure 22). Two operational methods can be used to move containers with the pontoon ferries: (1) Ro/Ro (roll-on/roll-off) – truck/trailers on the ferries with containers loaded directly onto the trailers at the ship so the unit can be driven ashore when the ferry beaches;* and (2) Lo/Ro (load-on/roll-off) – containers placed directly on the pontoon deck and unloaded at the beach using material-handling equipment (MHE).

During the first test, a five-section ferry loaded with 12 containers, which were positioned on the three sections adjacent to the shore, was beached, and a top-lift loader (TLL) moved the containers ashore. The TLL was a Hyster Challenger (Model H620B) container-handling lift truck with a high-mount, side-shift carriage (Figure 23). The TLL was leased from the Hyster Company, Long Beach, California, for $3,000 per month.

The TLL, which weighs 83,000 pounds (37.6 Mg), is capable of stacking the 8 x 8 x 20-foot containers two high. With a fully loaded container the weight on the front drive wheels is about 136,000 pounds (61,700 kg), resulting in footprint pressures of about 90 to 100 psi (621 to 689 kPa).

The high-mount, side-shift container carriage provides for articulation (forward and rear tilt of ±15 degrees and slew of ±5 degrees) and lateral adjustment of about ±18 inches. The operator is

*This method was tested in OSDOC II [7].

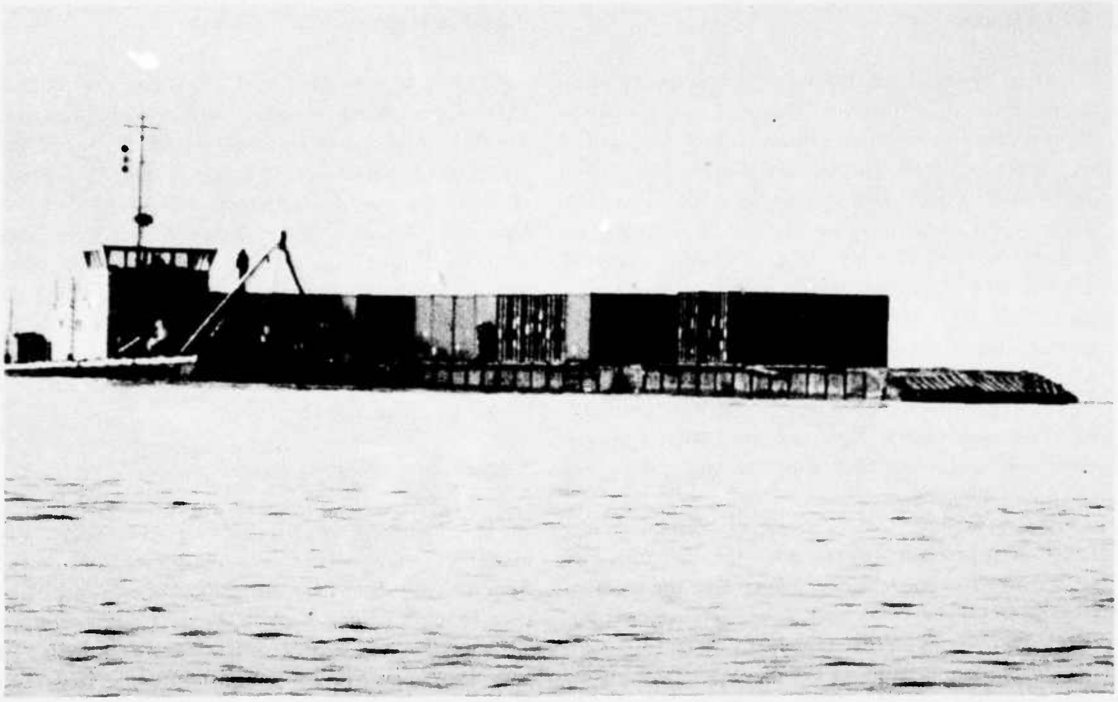


Figure 17. Three-section NL pontoon causeway ferry.

located about 12 feet above the ground, which gives an excellent view. Steel matting, M8A1, was positioned at the beach end of the ferry to permit operation of the TLL with container over the soft beach sand.

3.2.11 Air-Bearing Transporter

The air-bearing device [8] used to unstuff the containers at the beach consists of two thin 3-foot (0.9-m) wide by 20-foot (6-m) long pallets, each equipped with six 34-inch (864-mm) diameter air bearings. The air bearings, which are toroidal rubber bags forming a plenum chamber, operate at an air pressure of 4 psi (27.6 kPa); each bearing has a 10,000-pound (4.5-Mg) lift capacity so that the total system lift capacity is 120,000 pounds (54.4 Mg) (Figure 24). A standard 360-cfm (0.17 m^3/s) air compressor supplies the air for the system.

The 20-ton (18-Mg) weights in the containers were loaded on master pallets that would accept the 20-foot (6-m) long air transporter pallets. After the two air pallets are positioned under the loads, air is valved into load bars which inflate and raise the 20-ton (28-Mg) weights. The entire 20-ton (18-Mg) load can then be pulled from the container onto a level, smooth surface by two men. Cargo can be selected and the remainder returned to the container for storage.

Figure 18. Class 1610 LCU, moored to elevated pier.

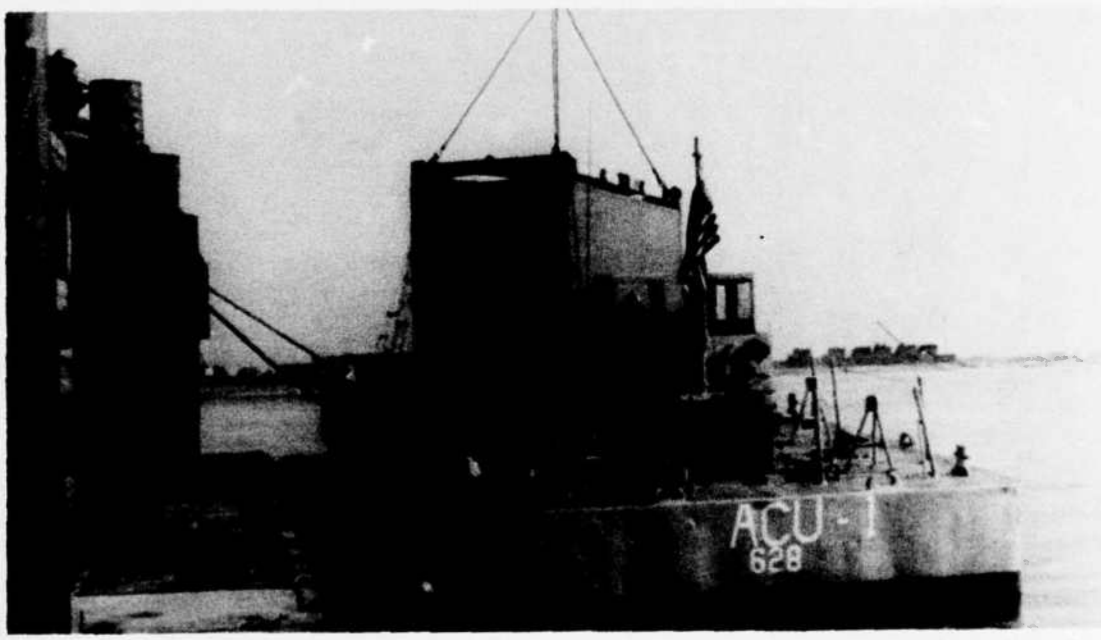


Figure 19. LCM-8 being unloaded while moored to pierhead and fender system.

Figure 20. Marine Corps truck/trailer (M52/M127) being rotated on turntable.

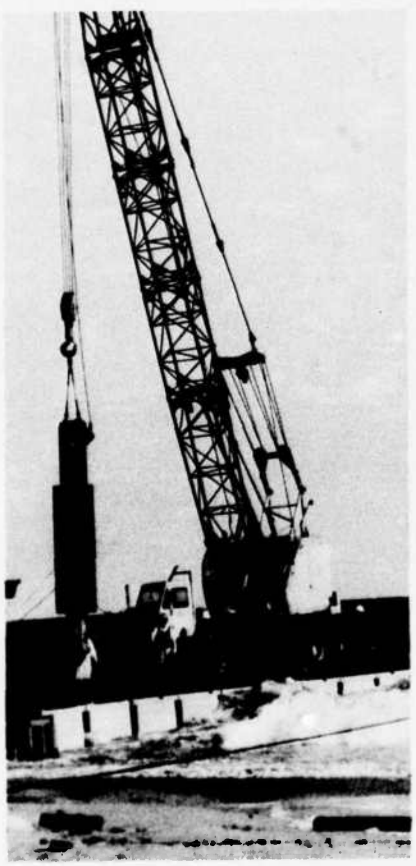


Figure 21. Model DE-30 diesel-operated pile hammer.

Figure 22. Causeway ferry beached for Lo/Ro operation.

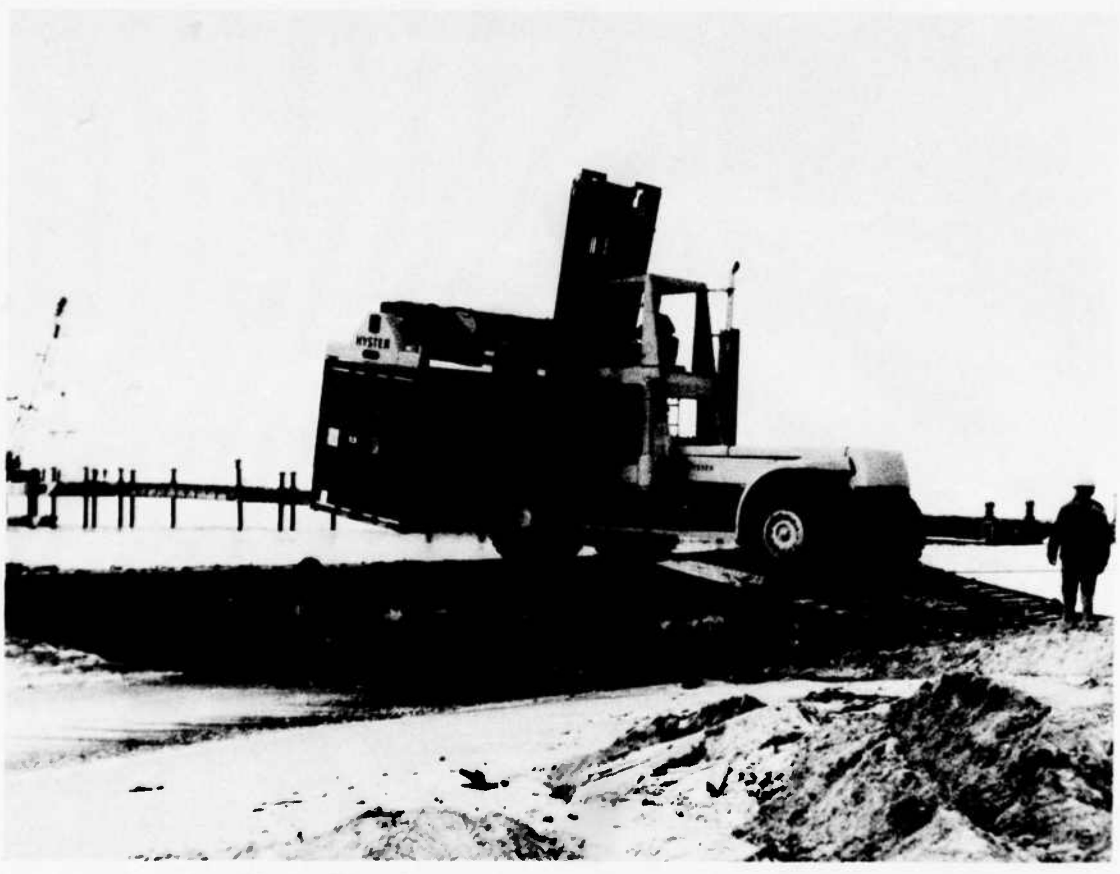


Figure 23. Top-lift loader removing 20-foot container from beached causeway during Lo/Ro test.

Figure 24. Air-bearing transporter.

SECTION 4

CONTAINER MOVEMENT SCENARIO

Average operating times were computed from the data collected during the Phase II tests (see Table 2). Operating times for the individual components, i.e., crane, trucks, turntable, and lighters, were identified (Table 3). From this information the following scenario was composed for transferring containers to the Elevated Causeway (Figure 25) and then to the beach. The water condition selected for the scenario is a 1-to-2-foot (0.3-to-0.6-m) swell with 2-foot (0.6-m) breakers; there is no wind blowing.

Table 2. Operation Times for Unloading Containers

Element	Operation Times (min) for –		
	Three-Section NL Pontoon Ferry	Class 1610 LCU	LCM-8
Moor lighter	6.7	2.4	3.5
Unload container			
Using manual spreader bar	2.3	2.2	2.7
Using slings	2.3	2.7	–
Warp lighter	3.0[a]	6.0[b]	–[c]

[a]Ferry must be warped five times to reach all 12 containers.

[b]LCU must be warped once to reach all four containers.

[c]LCM-8 does not require movement.

4.1 NL PONTOON CAUSEWAY FERRY

The three-section causeway ferry with 12 containers on the deck (the 20-foot (6-m) container dimension crosswise of the ferry) approaches the elevated pier and moors. Average time to moor the ferry is 6.7 minutes. The crane and truck/trailers are in position to receive the first container; see sketch on Table 3 of truck positions. Six truck/trailers are provided for the operation. Using the manual spreader bar, the crane moves the first container to the waiting truck (at Crane Position D) in the average time of 2.3 minutes (Figure 26); this is crane cycle operation 1, 2, 3, and 4 of Table 3. The second truck parked in the wait position (position B) must delay movement until the first truck with container passes position B. When clear, it moves (operation 6) to the turntable and then to the crane (operation 7). Meanwhile, the crane has lifted the second container and is waiting for the second truck, operations 1, 2, and 3. The crane sets the second container on the truck (operation 4). Average time for second container is 3.25 minutes.

It is necessary to warp the ferry along the pierhead after each pair of containers has been lifted because of the limited reach capacity of the crane. This adjustment of the ferry's position can begin after the second container has been lifted. Average time to warp the ferry once is 3 minutes. This time is concurrent with and less than truck movement operations 9, 6, and 7. Operation 2 for the crane is delayed until after the warping operation ends, but operation 3 is completed prior to operation 7 for the truck. Thus, no overall time loss is encountered because of the warping operation.

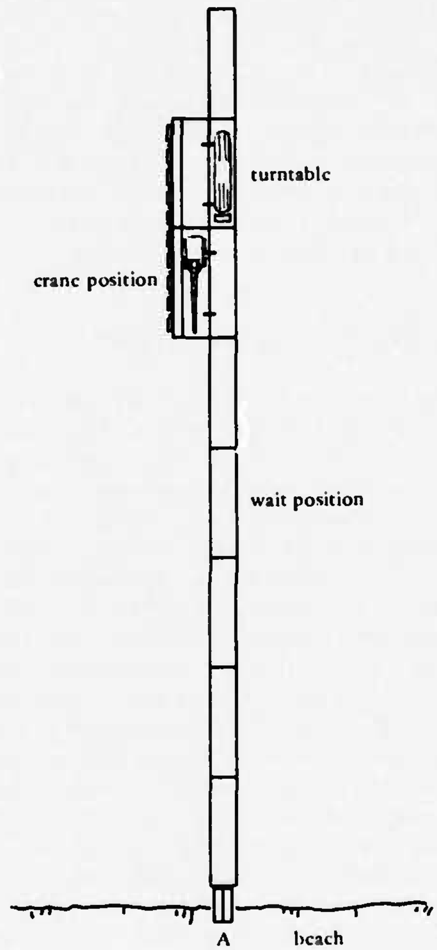
The average container-handling time of 3.25 minutes is typical for all containers following the first one. The last container requires 3.25 minutes to load on the truck, and then 2 additional minutes are required for the loaded truck to traverse the elevated causeway to the beach. All 12 containers are now ashore. The total unloading time is 40.05 minutes, which results in an average rate of 18 containers per hour. When the mooring time of 6.7 minutes for the ferry is added, the container rate is reduced to 15 to 16 containers per hour.

Figure 27 shows a time plot using data from the Phase II test for unloading the three-section pontoon ferry. The critical time path (heavy solid line on the

Table 3. Sequence of Unloading Operation

Cycle	Operation	Description	Time (sec)
Crane	1	Crane start, swing to container on lighter	39
	2	Lock onto container	27
	3	Lift container and swing to start position	55
	4	Load container on trailer	20
Truck	5	From beach to wait position	65
	6	Wait position to turntable	63
	7	Turntable to crane	79
	8	Crane position to beach	120
	9	Crane position to wait position	30
	10	Wait position to beach	90
Lighter[a]	11a	Warp ferry	180
	11b	Warp LCU	360

[a] LCM-8 does not require warping.



Truck positions on elevated pier.

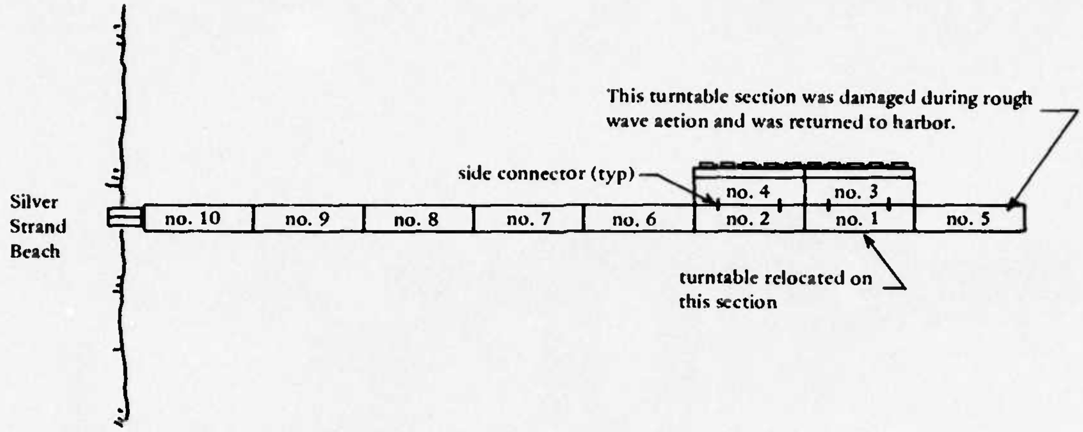


Figure 25. Location of sections of elevated causeway for Phase II operations.

plot) for container movement shows the truck cycle time to be the major time consumer (after ferry mooring). The original Phase II plan* would have made the truck movement time more concurrent with the crane cycle, thus eliminating the crane waiting time and shortening the overall time by about 8.8 minutes (average crane waiting time of 0.8 minute for each of 11 trucks; the first container has no crane delay as the equipment is in position before the ferry moors to the pierhead). This saving in time translates into a total rate of 19 containers per hour instead of 15.4 containers per hour.

When the truck cycle time is improved, the warping time may become the critical path component. The warping time required to adjust the ferry position to accommodate the reach/lift capability of the crane begins after the second container has been lifted from the ferry. In very calm water (no greater than lower sea state 2), which existed at the Phase II test site, it is safe for the crane to swing and lower the spreader bar to the containers on the ferry near the end of the warping tug cycle. It appears that considerable improvement can be made in reducing the warping time as the crews become more familiar with the operation.

4.2 CLASS 1610 LCU LIGHTER

The average mooring time for the LCU is only 2.4 minutes, while the time to warp the LCU is 6.0 minutes. The LCU needs to be moved only once during unloading compared to five times for the causeway ferry. The additional warping time of 6.0 minutes results in a delay for the crane cycle of about 3 minutes after each pair of containers, but the overall container-handling time is similar to that for the causeway ferry because of the shorter mooring time. Total time to transfer 12 containers or three LCU loads is 50.2 minutes or 14 containers per hour.

The lower plot in Figure 27 represents the time and operational sequence for unloading the LCU during the Phase II tests. The LCU carries only four containers; therefore, the plot has been extended for two additional LCUs (eight more containers) to compare times with the three-section ferry that carries 12 containers. The two additional LCUs are shown as being ready to moor to the elevated pier as soon as the preceding LCU departs the pierhead. The critical time path shown in the heavy solid line points out that the trucks and warping cycles are the dominating operations. Improving the truck cycle

*Plan changed when Section No. 5 was damaged and turntable had to be placed on the pierhead.

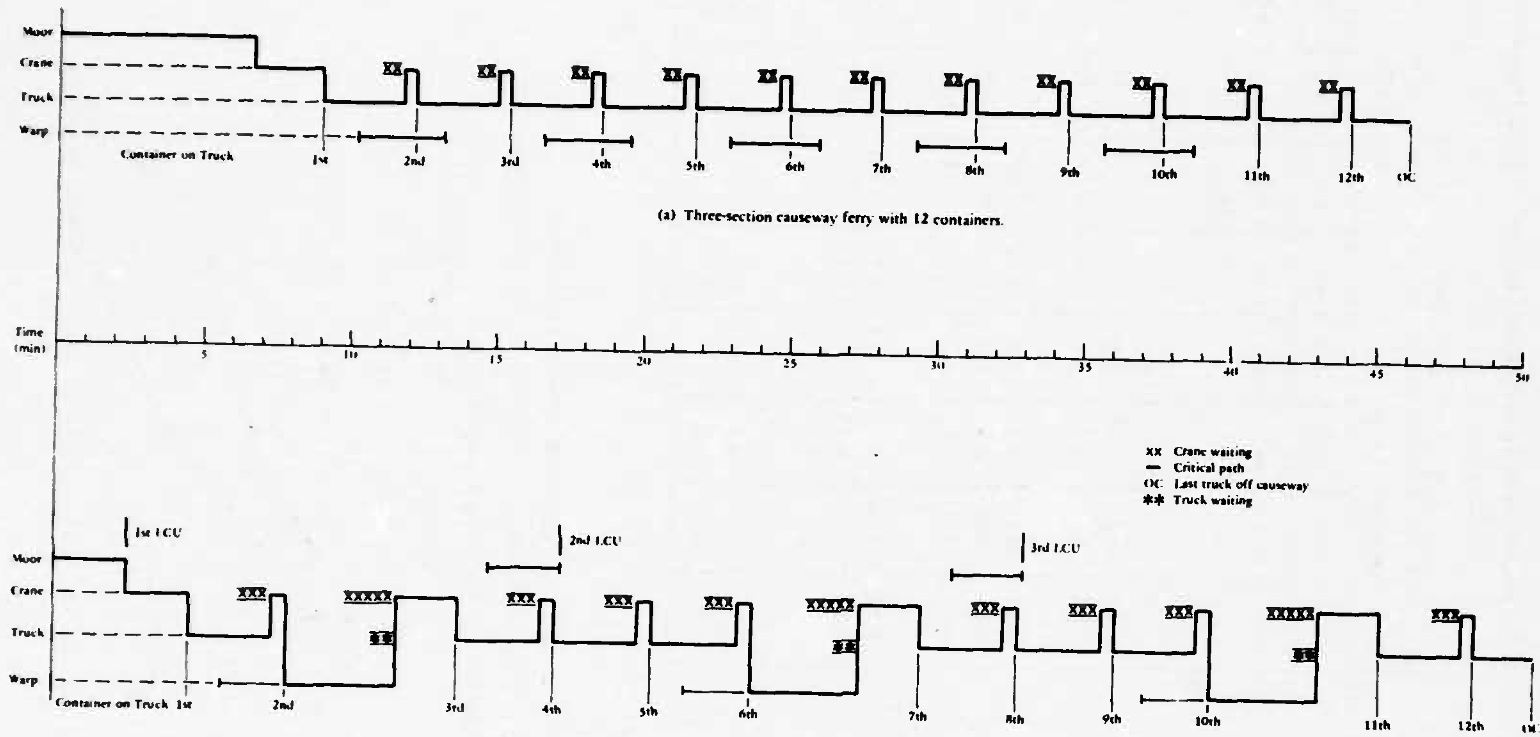
Figure 26. Unloading containers from three-section causeway ferry at elevated pierhead.

time by about 8.0 minutes* would increase the container rate per hour from about 14 to 17. Figure 27 illustrates 18 minutes of warping time for the LCU, of which about two-thirds is critical because the crane is waiting. Thus, any reduction in time that can be made, which should be considerable after the crews become experienced, would be reflected as an improvement in productivity.

4.3 ENVIRONMENTAL EFFECTS

The previous estimated container-handling rates are based on data obtained during a calm environment. With an increase in the wave and wind factors, the mooring and warping times for the lighters will become longer and the hook-up times for the crane/container/lighter operation will increase. The truck cycle time, including the turntable operation, will not be affected. Based on experience gained during the OSDOC I and II operations, Fort Story, Virginia, and the Engineering Tests for OSDOC II, Coronado, California, estimates were made to degradate the lighter/container lift operation. Table 4 lists the degradation to be expected in the container-handling rate because of increased lighter motions. The times listed for each operation in Table 4 are not directly additive to determine the total time, because some operations are concurrent, as illustrated in Figure 27. The crane cycle time will produce 20 containers per hour, but delays caused by lighter motions and truck maneuvering will reduce the container through-put to 15 containers per hour in calm waters and to 7 containers per hour in rough waters.

*Average improvement of 1.0 minute per truck can occur eight times in the LCU plot.



(a) Three-section causeway ferry with 12 containers.

(b) Three LCUs with Four Containers Each.

Figure 27. Elapsed time plot for lighter unloading operation.

Table 4. Estimated Degradated Container-Transfer Rates Between Lighter and Elevated Causeway

Operation	Container Transfer Rates (min) Using —							
	Three-Section Ferry				Class 1610 LCU			
	SS-1[a]	SS-2	SS-3	SS-4	SS-1	SS-2	SS-3	SS-4
Moor to pierhead	6.7	6.7	10	13	2.4	2.4	10	NR[b,c]
Warp along pierhead	3.0	3.0	5	8	6.0	6.0	8	NR
Unload Containers								
Rotate and lower unit								
Spreader bar	0.67	0.67	0.67	0.67	0.35	0.35	0.35	NR[d]
Sling	0.24	0.24	0.24	0.24	0.26	0.26	0.26	NR
Lock onto container								
Spreader bar	0.45	0.45	2.5	NR	0.46	0.46	5.0	NR
Sling	0.65	0.65	2.5	3.0	0.8	0.8	4.0	NR
Lift and rotate container	0.92	0.92	0.92	1.1	0.92	0.92	0.92	NR
Position and release container								
Spreader bar	0.38	0.38	0.38	0.38	0.38	0.38	0.38	NR
Sling	0.57	0.57	0.57	0.57	0.57	0.57	0.57	NR
Container retrograde[e]								
Position on lighter								
Spreader bar	2.1	2.1	2.6	3.1	1.8	2.0	6.0	NR
Sling	2.3	2.3	NR	NR	2.3	2.3	NR	NR

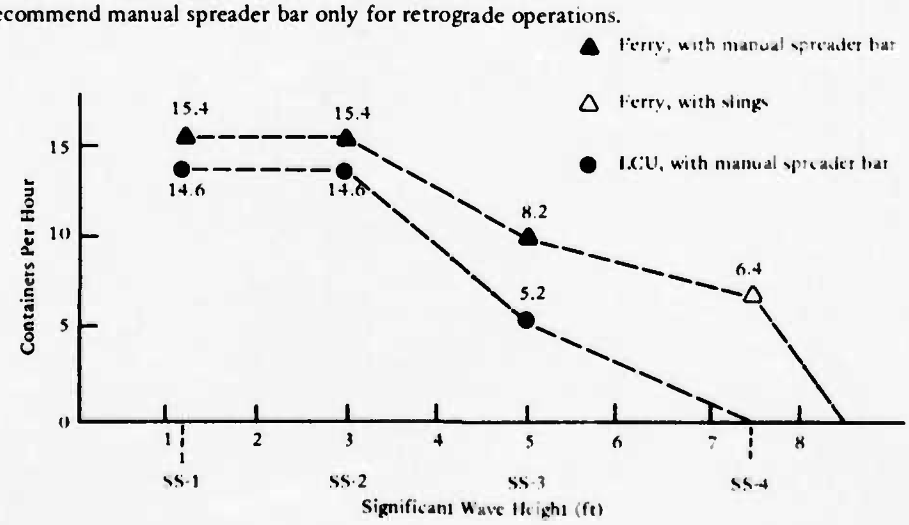
[a]SS = sea state, see diagram.

[b]NR = not recommended.

[c]Average time to moor LCU to elevated Delong (OSDOC II) was 13 min. <SS-3.

[d]Average time to unload LCU onto elevated Delong (OSDOC II) was 7.3 min. <SS-3.

[e]Recommend manual spreader bar only for retrograde operations.



SECTION 5

CRITIQUE

A meeting was held at the beach site on 4 December 1975 with all participating and observer personnel to identify those features of the operation, both equipment and procedures, that required improvement or modifications. The following items were proposed:

1. Beach causeway at high tide.

2. Drive all piles early.

3. Drive all piling, because tractor can separate or close end connectors.

4. Pile guides in all holes; use another crane to drive.

5. Better way to attach piles to sections other than by welding (bolt, using built-in setup on spudwell).

6. Have pile cut below truck bed level when moving truntable to position on pier.

7. Lighter weight pile driver (for control of swing).

8. Pile hammer leads.

9. Ladder from elevated sections to floating.

10. Reduce number of hydraulic hoses (chance for damage to hoses, plus handling problem).

11. Gimbals integral to system, rather than handle separately.

12. Sections had bow-in alignment; could have been straightened out, which might have made reconnection of end connectors easier after elevation.

13. Side connectors were not accessible for connecting up (better system needed).

14. Better way to attach timbers to pontoon deck (tractor rips tie bars off); must accommodate tractor traffic.

15. Clearance around turntable for swing.

16. Continuous roadway for truck operation (at end connectors).

17. Tie up lighterage to fender; arrange line tie points where they will not be under containers during lift.

18. Welders had to wait to get into position to weld (sequence of operation).

19. Welding sequence endangered welders; delays for welders.

20. Scaffolding for welding over sides (better equipment).

21. Safety: welders working down inside of spudwell with equipment passing overhead; did not know when welder might stick his head out.

22. Most dangerous parts of operation: handling gimbals outside of spudwell; welders hanging (scaffolding) over the side; setting and driving pile using pile driver.

23. Operational concept: material handling from beach; weight of pile driver (tie-down control of lines to hammer).

24. Priority for movement of equipment onto pier during elevation (NELC).

25. Who should be in charge of operation? Rate? No decision. (E8, EO Chief, BMC or steel worker chief).

26. Brief working people on total project sequence.

27. Identify crews for each operation.

28. System should not be any more complicated than at present (for personnel training).

29. Training for crane signal/riggers.

30. Communications to beach from pierhead: hard wire, radios.

31. Too many people taking pictures; interferred with operation.

SECTION 6

FOLLOW-ON PROGRAM

Component modifications recommended by PHIBCB-ONE and/or CEL evaluators are planned to be investigated during the period February to October 1976. Items which have been identified include:

1. Modify lift pads on spudwells to provide a clear deck.

2. Improve pile hammer leads.

3. Improve method of securing sections to piling in order to eliminate or reduce welding and other associated hazards.

4. Modify jack system relative to number of hydraulic hoses.

5. Improve side-connector system.

6. Revise method of mounting external spudwells onto section.

7. Provide improved, safer ladder system.

8. Investigate pedestal crane system for pierhead.

9. Improve foam cushion rigging arrangement and add mooring bitts to fender string.

10. Extend turntable to handle 40-foot (12.2-m) container trailer.

11. Investigate multisection elevation.

Concurrent with this program, an investigation will be initiated to develop elevated causeway options of support equipment that can be made available for the joint Army/Navy exercise LOTS (Logistics-Over-The-Shore) to be conducted in 1977 on the East Coast.

SECTION 7

ACKNOWLEDGMENTS

The following organizations provided direction, equipment, experience, and personnel necessary to achieve the excellent results of the advanced development tests. Without their cooperation and support the program could not have been accomplished:

- Commander, Naval Surface Forces, Pacific, authorized the Amphibious Units to support the program.
- Commander, Naval Beach Group, Amphibious Refresher Training Group, Coronado, approved and coordinated the beach support operations.
- Amphibious Construction Battalion One provided the personnel and equipment to direct, install, and operate the elevated causeway.
- Amphibious Assault Craft Unit One furnished the LCU landing craft and crews used to ferry the containers.
- First Force Service Regiment, First Marine Division, Camp Pendleton, California, provided the drivers and truck/trailers used to move the containers on the causeway.
- Naval Ship Research Development Center, Carderock, Maryland, conducted the motion measurements and analysis for the lighters moored to the pierhead.
- Naval Electronics Laboratory Center, Human Factors Division, Code 3400, San Diego, provided the human engineering study of the elevated causeway system.
- Public Works Center, U.S. Naval Station, San Diego, fabricated the spudwells, installed and load-tested the external spudwells, and provided welders during the operation.
- Construction Equipment Department and Marine Terminal Division, NCBC, Port Hueneme, assembled all of the pierhead pontoon sections.
- Transportation Division, NCBC, Port Hueneme, provided operators and a construction crane for both the Phase I and Phase II tests.
- CEL Support Operations Department; Logistics Support Division; Planning Branch; and Technical Support Branch.

SECTION 8

REFERENCES

1. David Taylor Naval Ship Research and Development Center. Report SPD-515-02: "An investigation of the absolute lighter motions involved in the container offloading and transfer system (COTS) trials," by L. C. Ruth, Mar 1976.

2. Civil Engineering Laboratory. Plan for Advanced Development Tests – COTS, Aug 1975.

3. ———. Preliminary Report (in-house): "Container off-loading and transfer system, advanced development tests," Sep 1975.

4. ———. 16-mm movie, sound, color, 22 minutes: "Elevated causeway tests," (Phase I tests). Pt. Mugu, CA, Jun 1975.

5. ———. 16-mm movie, sound, color, 25 minutes: "Elevated causeway advanced development tests," (Phase II tests). Coronado, CA, Nov 1975.

6. ———. Technical Report R-826: "Lift system for elevated causeways," by C. I. Skaalin. Port Hueneme, CA, Nov 1975.

7. Joint OSDOC II Plans and Operations Group, Joint Army-Navy Test Directorate. "Offshore discharge of containership, OSDOC II, Test and Evaluation, 3-14 October 1972. Fort Story, VA, May 1973.

8. Civil Engineering Laboratory. Technical Note N-1385: "An evaluation of air-bearing systems for cargo movement in Marine Corps supply," by M. J. Wolfe. Port Hueneme, CA, Mar 1975.

Appendix A

CHRONOLOGY OF PHASE II TESTS

A. PIER ELEVATION

Wednesday, 12 Nov 1975

0915 – Causeway beached.

1630 – Six piles driven, and beach ramp set (delay due to repair of pile hammer leads).

Thursday, 13 Nov 1975

0800 – Began driving four piles in Section No. 9 (second section from beach, see Figure 25).

1010 – Began moving jacks to piling on Section No. 9.

1140 – Control panel set on Section No. 10.

1230 – Disconnected links between Section No. 9 and Section No. 8.

1450 – Section No. 9 raised into position; this also raised offshore end of Section No. 10 through end connection to Section No. 9; began welding gussets between pile and section.

1550 – Began welding gussets to piles on Section No. 9.

Friday, 14 Nov 1975

0715 – Began welding gussets on Section No. 9, moving jacks to Section No. 8.

1330 – Moved jacks, began elevating Section No. 8. (Pile driving crew stopped working during test on separation of sections.)

1430 – End-connected Sections No. 8 and No. 9.

1650 – Final elevation completed on Section No. 8; drove four piles in Section No. 7.

Monday, 17 November 1975

0700 – Surf 4 to 5 feet (1.2 to 1.5 m); delayed operation due to filling sand at ramp end, and crane operation delayed because of 6-foot (1.8-m) breakers.

1325 – Crane began cutting outriggers on Section No. 7.

1343 – Began setting jacks on Section No. 7.

1428 – Delay in operation caused by one jack being damaged.

1527 – Spare jack installed.

1622 – Began driving pile in Section No. 2.

1630 – Began elevating Section No. 7.

Tuesday, 18 Nov 1975

0715 – Waves, 3 to 4 feet (0.9 to 1.2 m); Section No. 7 has been elevated to Section No. 8, but not end-connected.

0735 – 6-to-6.5-foot (1.8-to-2-m) breakers at Section No. 6.

1225 – Section No. 7 end-connected and raised into position.

1400 – Section No. 5 with turntable broken loose except for one pile; Section No. 5 returned to harbor.

Wednesday, 19 Nov 1975

0700 – Surf, 2 to 3 feet (0.6 to 0.9 m).

0845 – Pulled hydraulic pump on jack system for repair.

1005 – Began driving pile in Section No. 6.

1230 – One pile in Section No. 6 was broken; hydraulic pump repaired and being installed in power unit.

1400 – Began driving pile in Section No. 4.

Thursday, 20 Nov 1975

0725 – Breakers, 1 to 1.5 feet (0.3 to 0.5 m); five sections yet to be elevated: No. 1, 2, 3, 4, and 6.

0855 – Began laying steel mat for Lo/Ro.

0910 – Began replacing broken pile in Section No. 6.

0947 – Began transferring jacks to Section No. 6.

1035 – Fourth jack in position on Section No. 6.

1046 – Beached Lo/Ro ferry.

1055 – Began welding gussets on pile in Section No. 7.

1150 – Completed sand ramp for Lo/Ro ferry.

1245 – Began elevating Section No. 6.

1250 – Top-lift loader approaching Lo/Ro ferry.

1251 – Top-lift loader locked onto Container No. 1.

1350 – Began driving piles in Sections No. 1 and 2.

1425 – Section No. 6 elevated, delay in end-connecting.

1515 – All piles driven in Sections No. 1 and 2.

1611 – Twelfth container removed from ferry.

1900 – Lo/Ro ferry removed from beach at high tide.

Friday, 21 Nov 1975

0725 – Surf, 1 to 3 feet (0.3 to 0.9 m).

0845 – Gimbals being transferred from Section No. 6 to Section No. 2.

1028 – Jacks in position.

1035 – Began elevating Section No. 2.

1320 – End-connected Sections No. 2 and No. 6.

1452 – Began moving jacks to Section No. 1.

1533 – Jacks in position.

1730 – Section No. 1 with crane on board elevated to Section No. 2 end-connector height and secured for the evening.

Saturday, 22 Nov 1975

0710 – Surf, 1 to 2 feet (0.3 to 0.6 m).

0930 – Delay in removing crane from Section No. 1.

1145 – Began raising Section No. 1 into position with Section No. 2.

Sunday, 23 Nov 1975

0900 – Elevated Section No. 4.

1230 – Elevated Section No. 3.

1530 – All sections elevated and end-connected.

Monday, 24 Nov 1975

0700 – Began welding gussets onto Sections No. 3 and 4.

0930 – Fender system arrived offshore.

1000 – Two center piles driven in Section No. 4.

1125 – Began installing piles in external spudwells on Section No. 10.

1418 – First pile driven in fender spudwell.

1445 – Second pile driven in fender spudwell.

1600 – All piling placed in fender system.

Tuesday, 25 Nov 1975

0725 – Water calm.

0915 – Began retrieving fender piling to deeper penetration.

1325 – Instrumentation shacks set on pierhead, turntable set on Section No. 1.

Wednesday, 26 Nov 1975

0730 – Breakers, 1 to 3 feet (0.3 to 0.9 m).

0850 – Began setting exterior spudwells on off-shore end of Section No. 10.

0857 – Turntable being checked and rotated.

1000 – Began moving second exterior spudwell to Section No. 10, piling installed and pier cleared for container tests on Monday, 1 Dec 1975.

B. CONTAINER HANDLING

Monday, 1 Dec 1975

0630 – Water calm, container crane on beach.

0645 – Center boom section for crane arrived, 1 hour to insert center section.

1400 – Container crane moved out onto pier.

1430 – Crane being maneuvered into position on Section No. 4.

1435 – Top-lift loader setting containers on Marine Corps trucks.

1530 – Crane set, containers loaded on six trucks.

Tuesday, 2 Dec 1975

0630 – Water calm.

0825 – Load cells for fender test set.

0845 – Three-section ferry 100 feet (30.5 m) from pier.

0847 – First truck with container parked under crane for backloading operation.

0953 – Ferry tied to pier (delay caused by cherry picker removing welding machine from pierhead).

0958 – Second truck arriving at crane, delay in turntable operation.

1030 – Ninth truck with container under crane.

1055 – Ferry backloaded and pulled away.

1107 – Ferry tied to pierhead.

1150 – Ferry unloaded (12 containers).

1245 – Backloading onto ferry.

1340 – Containers loaded onto ferry and ferry backing away, delay caused by turntable malfunctioning.

1357 – Ferry tied to pierhead (8 minutes required).

1359 – First container set on truck.

1435 – Twelfth container removed from ferry.

Wednesday, 3 Dec 1975

0630 – Water calm.

0900 – Sand ramp to beach repaired, LCU-1652 tied to pierhead at Section No. 3 for fender test.

0910 – First truck proceeding to pierhead.

0915 – First truck loaded and on way to beach.

0925 – Fourth truck (last container from LCU) loaded on truck.

0930 – LCM-8 approaching pierhead (two containers).

0937 – First container on truck.

0941 – Second container on truck and headed to beach.

0954 – LCU tied up, and first container being backloaded.

1008 – Four containers on LCU.

1015 – LCM-8 alongside pierhead.

1028 – One container backloaded, operation delayed because crane battery cable failed.

1031 – Began unloading LCU.

1048 – Fourth container on truck.

1050 – LCM-8 tied up.

1052 – Container being lifted.

1055 – LCM-8 returning to pierhead (35 seconds to secure two lines).

1100 – LCM-8 backloaded and leaving (one container).

1115 – LCU approaching pierhead to be backloaded.

1128 – Fourth container set on LCU.

1338 – LCM-8 approaching pierhead (3 minutes to tie up and lift container).

1434 – LCU approaching pierhead.

1449 – Four containers loaded onto LCU.

1455 – LCU tied to pierhead.

1510 – Last container removed from LCU.

Thursday, 4 Dec 1975

0625 – Water calm, 2-foot (0.6-m) breakers.

0815 – Set up for Lo/Ro test, back-blade sand with tractor.

0900 – Three-section ferry beached for Lo/Ro test.

0955 – Six containers removed from Lo/Ro ferry by top-lift loader.

1025 – Six containers removed from Lo/Ro ferry by top-lift loader.

1221 – Began to backload four containers onto LCU using slings.

1251 – Completed loading containers onto LCU at pierhead using slings.

1300 – Began lifting first container from LCU using slings.

1312 – Last container lifted from LCU.

1315 – Last container loaded onto truck.

1400 – Critique held on beach with PHIBCB-ONE; see Section 5, CRITIQUE.

Friday, 5 Dec 1975

0610 – Water calm.

0723 – First container lifted from truck using slings and backloaded onto three-section ferry at pierhead.

0813 – Twelfth container on causeway ferry.

0821 – Began removing containers from ferry at pierhead.

0850 – Twelfth container off of ferry.

0905 – First container being backloaded onto ferry at pierhead.

0945 – Seventeenth container on causeway ferry (awaiting 18th container, which is being unstuffed at beach).

1005 – Eighteenth container being loaded onto truck at beach.

1010 – Eighteenth container loaded onto ferry.

1020 – Container crane being maneuvered off of pierhead.

1045 – Container crane on beach, pier secured until 5 Jan 1976.

C. PIER RETRIEVAL

Monday, 5 Jan 1976

0900 – Began removing jacks from container.

1145 – Began pulling fender pile.

1253 – First fender pile removed.

1437 – Sixth fender pile removed.

1438 – Pontoon tug pulling fender section away.

1450 – Began pulling interior piling on Section No. 4.

1525 – Set first jack on Sections No. 3 and No. 4.

1555 – Interior pile removed.

Tuesday, 6 Jan 1976

0820 – Second jack set on pile, side connectors released between Sections No. 1 and No. 3.

0900 – Third jack set on pile.

1000 – Fourth jack set on pile, side connectors released between Sections No. 2 and No. 4.

1045 – Burned gussets from piling.

1150 – Began lowering two sections together, jacks on diagonal corners.

1345 – Sections floating, began removing jacks.

1502 – Fourth jack set on pile on Section No. 6.

Wednesday, 7 Jan 1976

0900 – Began pulling piling from Sections No. 3 and No. 4.

1217 – Piling removed from Sections No. 3 and No. 4, and pontoon tug returning sections to harbor.

1300 – Began to disconnect end connectors between Sections No. 6 and No. 2.

1630 – Separated Sections No. 6 and No. 2.

Thursday, 8 Jan 1976

0820 – Began lowering five sections while end-connected.

1550 – Five sections lowered into water.

1555 – Began transferring jacks to Sections No. 1 and No. 2.

1650 – Jack transfer completed.

Friday, 9 Jan 1976

0645 – Began pulling piling from five floating sections.

0920 – Chains and turnbuckles removed from Sections No. 1 and No. 2 and lowering begun.

1415 – Sections No. 1 and No. 2 lowered, and reconnection of Sections No. 2 and No. 6 begun.

1609 – Jacks removed from piling.

Saturday, 10 Jan 1976

0750 – Began end-connecting Sections No. 2 and No. 6.

0755 – Sections No. 2 and No. 6 end-connected.

0903 – Began removing piling.

1124 – Crane removing last jack from piling.

1241 – Last pile removed.

1245 – Crane off causeway.

1305 – Beach ramps removed.

1312 – Causeway off beach, beach cleanup begun.

Appendix B

ENVIRONMENTAL MEASUREMENTS

by D. A. Davis

This appendix presents summaries of environmental measurements made during both the Phase I (Point Mugu site) and Phase II (Coronado site) elevated causeway tests. These data are useful for assessing the performance of the fender as well as other subsystems of the elevated causeway project.

PHASE I TESTS

Waves Offshore

The amplitude and frequency of the waves offshore at the beach test site were measured with an instrumented, surface-following buoy (Datawell-Laboratory Waverider) that was moored about 300 yards (274.3 m) from shore in a southwesterly direction from the elevated causeway.* The water depth at the time of installation was approximately 25 feet (7.6 m). The telemetered signal from the buoy was received at CEL, Port Hueneme, and recorded on strip chart paper.

Ten-minute segments of recorded data were analyzed to determine the maximum recorded wave height and the dominant swell period. The results of this analysis for three 10-minute periods beginning at 0800, 1200, and 1600 hours for the more critical test days appear in Table B-1.

Except for visual estimates from the beach and elevated causeway, no directional measurements, such as aerial photography, were made of the waves and swell. Although these visual estimates are not precise, they did indicate that the swell was approaching from a southerly direction. For the test location, southerly swell during the summer months is commonly due to tropical storms off the coast of Mexico and locations farther south.

Waves Near Shore

The breaker height, breaker angle, and number of breakers were determined visually from the beach or elevated causeway. The dominant period of the breakers was determined visually with the aid of a stopwatch.

During the period of testing from 19 June to 16 July, two tropical storms occurred off the coast of Mexico that generated heavy swell at the test site. On 7 and 8 July, for example, breakers in excess of 8 feet (2.4 m) were noted.

Surf observations for selected days of testing are summarized in Table B-2.

Current Near the Elevated Causeway

An electromagnetic water current meter was installed approximately 100 yards (91.4 m) seaward of the causeway. This meter is capable of measuring both the speed and direction of quasi-steady alongshore currents. Speed and directional data are recorded on a self-contained strip chart recorder.

Unfortunately, no useful data were obtained from this instrument. Water particle velocities induced by passing waves, which are oscillatory in nature, obliterated any measurements of alongshore currents. However, on those occasions when the CEL warping tug was operating in the vicinity of the test site, surface currents were not assessed to be a significant factor in tug operations.

During periods of heavy swell, rip currents normal to the shore were noted. These short-duration, high-velocity flows extended perhaps 100 to 200 feet (30.5 to 61.0 m) beyond the end of the causeway.

Weather

Weather observations, which are summarized in Table B-3, were made by the Geophysics Division of the Pacific Missile Test Center, Point Mugu, California. This weather station is located about 1-1/2 miles (2.4 km) northwest of the test site. Except for occasional light morning fog and haze and a few days of overcast, skies were clear, and visibility was excellent during the test. Winds were westerly and rarely exceeded a speed of 10 knots (5.1 m/sec).

*The wave buoy was supplied and installed by the Geophysics Division of the Pacific Missile Test Center, Point Mugu, California.

PHASE II TESTS

Waves Offshore

Several days prior to beaching the causeway, the CEL Waverider buoy was moored about 250 yards (229 m) from shore. The water depth at the time of installation was approximately 25 feet (7.6 m). The site chosen was 250 yards (229 m) up the coast from boat lane 6 – close enough to the test site to yield representative wave data yet far enough away to avoid interference with the test activities.

For most of the test period, telemetered signals from the buoy were received at the PHIBCB-ONE Operations Building and recorded on strip chart paper. However, during the container-unloading tests of the week of 1 December, the buoy signal was recorded on magnetic tape by personnel from the David Taylor Naval Ship Research and Development Center (DTNSRDC).

A second wave transducer, which was an acoustic device, was installed at the seaward end of the pierhead.

As was the case with the Point Mugu data, 10-minute segments of wave data were analyzed to determine the maximum recorded wave height and the dominant swell period; the results appear in Table B-4. Generally, calm seas and swell persisted throughout the test period from 11 November to 5 December 1975 and during causeway retrieval in January 1976. The calmest conditions occurred during the container-handling exercises of the week of 1 December.

The highest waves were noted by beach observers to have occurred on 28 and 29 November. Estimates of wave height at the end of the pier ranged up to 8 feet (2.4 m). Unfortunately, a power failure prevented the recording of wave data on these two days.

Visual estimates indicated that the prevailing direction of swell was from the southwest.

Waves Near Shore

The breaker height, breaker type, breaker angle, and number of breakers were determined visually from the beach. The dominant period of the breakers was determined by counting the number of breakers that occurred in a given time interval. The data appearing in Table B-5 are the composite records of observers from CEL and Naval Beach Group-ONE.

Current Near the Elevated Causeway

The electromagnetic water current meter was installed near the Waverider wave buoy at a depth of about 30 feet (9.1 m). The site at Coronado was farther seaward of the surf zone than the site at Point Mugu. Thus, it was reasoned, there would be less interference with the alongshore current measurements from near-breaking waves. However, inspection of the first week's record again indicated considerable interference. No evidence of a quasi-steady state alongshore current was discernible. The current meter was then re-installed in deeper water.

Sometime during the high seas of 28 and 29 November, a rigging failure occurred which separated the flotation assembly from the submerged current meter. Several attempts by Navy divers to locate the device on the bottom and a thorough search of the beach were unsuccessful. Clearly, a different method is needed for measuring currents in the vicinity of the elevated pier.

Observers atop the pier did note a pronounced north-to-south alongshore current [approximately 2 knots (1.0 m/sec)] which, at times, affected lighterage operations. During the fender installation, for example, the warping tug pilot had to make several approaches against the current before he was able to maneuver the fender into position. Lighterage berthings were gentle, aided in part by the mild sea conditions and the current tending to hold the craft away from the fender.

Weather

Table B-6 summarizes weather observations obtained from the Naval Weather Service Facility at North Island. This weather station is located about 3 miles (4.8 km) northwest of the site of operations. Clear skies and mild westerly winds prevailed throughout most of the test period.

Table B-1. Height and Period of Dominant Swell Measured by Wave Buoy at Point Mugu Test Site[a]

Date/Time	Height[b] (ft, m)	Period (sec)	Test Activity
19 Jun			Beach causeway
0800	2.4 (0.73)	13.6	
1200	3.3 (1.00)	14.7	
1600	–	–	
20 Jun			Elevate causeway
0800	2.0 (0.60)	15.2	
1200	2.0 (0.60)	12.9	
1600	2.1 (0.64)	13.3	
23 Jun			Elevate causeway
0800	1.7 (0.51)	16.7	
1200	1.8 (0.54)	16.0	
1600	1.6 (0.48)	17.4	
24 Jun			Elevate causeway
0800	1.9 (0.57)	19.2	
1200	2.0 (0.60)	18.1	
1600	2.5 (0.76)	15.6	
25 Jun			Elevate causeway
0800	2.8 (0.85)	15.3	
1200	2.7 (0.82)	15.7	
1600	2.1 (0.64)	15.7	
30 Jun			Install fender
0800	2.5 (0.76)	16.3	
1200	2.4 (0.73)	15.8	
1600	2.3 (0.70)	16.0	
9 Jul			Fender impact test
0800	3.2 (0.98)	14.1	
1200	–	–	
1600	–	–	
11 Jul			Remove fender
0800	2.9 (0.88)	13.5	
1200	3.4 (1.04)	12.8	
1600	3.3 (1.01)	14.3	
15 Jul			Remove causeway
0800	2.2 (0.67)	11.8	
1200	3.2 (0.98)	12.2	
1600	3.2 (0.98)	12.2	
16 Jul			Remove causeway
0800	2.3 (0.70)	14.3	
1200	2.6 (0.79)	12.1	
1600	2.8 (0.85)	13.9	

[a]Water depth at buoy location was approximately 25 feet.

[b]Maximum recorded height in 10-minute period beginning at indicated hour.

Table B-2. Waves Near Shore at Point Mugu Test Site

Date/Time	Breaker Height (ft, m)	Dominant Period (sec)	Breaker Direction[a] (deg)	No. of Lines of Breakers	Test Activity
19 Jun					Beach causeway
0745	2.0-3.5 (0.61-1.07)	15.0	15(L)	2	
1045	2.5-3.5 (0.76-1.07)	15.0	5(L)	1-2	
1600	2.5-3.5 (0.76-1.07)	15.0	15(L)	2	
20 Jun					Elevate causeway
0900	2.5-3.0 (0.76-0.91)	14.0	10(L)	1-2	
1200	2.0-3.5 (0.61-1.07)	15.0	10(L)	1-2	
1600	2.5-4.0 (0.76-1.22)	16.0	10(L)	1-2	
23 Jun					Elevate causeway
0800	2.0-3.0 (0.61-0.91)	14.5	5(L)	1-2	
1200	2.5-4.0 (0.76-1.22)	15.0	15(L)	1-2	
1600	2.0-3.0 (0.61-0.91)	16.0	5(L)	1-2	
24 Jun					Elevate causeway
0900	2.5-4.5 (0.76-1.37)	15.0	20(L)	1-2	
1200	3.0-6.0 (0.91-1.83)	17.0	20(L)	1-2	
1600	2.0-4.0 (0.61-1.22)	17.0	25(L)	1-2	
25 Jun					Elevate causeway
0900	2.0-4.0 (0.61-1.22)	14.0	15(L)	1-2	
1200	3.0-6.0 (0.91-1.83)	15.0	20(L)	1-2	
1500	2.0-4.0 (0.61-1.22)	13.0	30(L)	1-2	
30 Jun					Install fender
0900	2.0-3.0 (0.61-0.91)	15.0	15(L)	2	
1300	2.0-4.0 (0.61-1.22)	12.0	15(L)	1	
1500	2.0-4.0 (0.61-1.22)	14.0	10(L)	1-2	
7 Jul					
0900	4.0-6.0 (1.22-1.83)	14.0	0	2	
1200	4.0-7.0 (1.22-2.13)	15.0	0	2	
1400	5.0-8.5 (1.52-2.59)	13.0	10(L)	2	
9 Jul					Fender impact test
0810	3.0-5.0 (0.91-1.52)	14.0	0	1	
1500	3.0-5.0 (0.91-1.52)	15.0	5(R)	1-2	
11 Jul*					Remove fender
0900	3.0-5.0 (0.91-1.52)	15.0	10(R)	2	
1300	2.5-4.0 (0.76-1.22)	13.5	0	1	
15 Jul					Remove causeway
0900	2.5-4.0 (0.76-1.22)	15.0	30(L)/0	1	
1200	2.0-3.0 (0.61-0.91)	15.0	30(L)/0	1	
1400	3.0-4.0 (0.91-1.22)	13.0	30(L)/0	1	

[a]Acute angle between breaker crest and shoreline. An R or L after entry means breaker advances toward right (or left) flank as seen from seaward.

*NOTE: Two waves approximately 7-8 ft (2.1-2.4 m) high occurred during extraction of final fender pile.

Table B-3. Climatic Data Summary for Point Mugu Test Site[a]

Date/Time	Wind Direction (deg)	Wind Speed (kt, m/sec)	Air Temperature (°F, °C)	Visibility (mi, m)	Weather and Obstruction to Visibility	Test Activity
19 Jun						Beach causeway
0800	–	0 (0.0)	61 (16.1)	5 (8.0)	haze	
1200	270	9 (4.6)	64 (17.8)	7 (11.3)		
1600	280	6 (3.1)	64 (17.8)	15 (24.1)		
20 Jun						Elevate causeway
0800	160	3 (1.5)	61 (16.1)	10 (16.1)		
1200	240	6 (3.1)	64 (17.8)	15 (24.1)		
1600	250	6 (3.1)	65 (18.3)	15+ (24.1+)		
23 Jun						Elevate causeway
0800	–	0 (0.0)	60 (15.6)	2.5 (4.0)	fog	
1200	260	4 (2.1)	63 (17.2)	2.5 (4.0)	haze	
1600	260	6 (3.1)	62 (16.7)	3 (4.8)	haze	
24 Jun						Elevate causeway
0800	250	2 (1.0)	60 (15.6)	3 (4.8)	fog/haze	
1200	260	4 (2.1)	64 (17.8)	4 (6.4)	haze	
1600	260	8 (4.1)	65 (18.3)	10 (16.1)		
25 Jun						Elevate causeway
0800	–	0 (0.0)	58 (14.4)	10 (16.1)		
1200	280	10 (5.1)	71 (21.7)	15 (24.1)		
1600	270	6 (3.1)	71 (21.7)	15+ (24.1+)		
30 Jun						Install fender
0800	–	0 (0.0)	61 (16.1)	4 (6.4)	fog/haze	
1200	250	5 (2.6)	65 (18.3)	10 (16.1)		
1600	270	6 (3.1)	62 (16.7)	10 (16.1)		
9 Jul						Fender impact tests
0800	–	0 (0.0)	63 (17.2)	5 (8.0)	ground fog	
1200	270	6 (3.1)	69 (20.6)	7 (11.3)		
1600	270	7 (3.6)	71 (21.7)	7 (11.3)		
11 Jul						Remove fender
0800	300	3 (1.5)	65 (18.3)	5 (8.0)	ground fog	
1200	260	8 (4.1)	71 (21.7)	7 (11.3)		
1600	270	8 (4.1)	71 (21.7)	7 (11.3)		
15 Jul						Remove causeway
0800	–	0 (0.0)	60 (15.6)	3 (4.8)	fog	
1200	250	5 (2.6)	66 (18.9)	4 (6.4)	fog/haze	
1600	270	5 (2.6)	65 (18.3)	2.5 (4.0)	fog/haze	
16 Jul						Remove causeway
0800	050	3 (1.5)	60 (15.6)	1.5 (2.4)	fog	
1200	180	6 (3.1)	68 (20.0)	2.5 (4.0)	fog	
1600	270	4 (2.1)	67 (19.4)	6 (9.7)	haze	

[a]Observations made by the Geophysics Division of the Pacific Missile Test Center. Weather station is located approximately 1-1/2 miles (2.4 km) from the Laguna Point test site.

Table B-4. Height and Period of Dominant Swell Measured by Wave Buoy at Coronado Test Site[a]

Date/Time	Height[b] (ft, m)	Period (sec)	Test Activity
11 Nov			
0800	—	—	
1200	3.6 (1.10)	12.1	
1600	5.1 (1.55)	11.1	
12 Nov			Beach causeway
0800	3.8 (1.16)	11.6	
1200	3.0 (0.91)	11.3	
1600	3.4 (1.04)	11.6	
13 Nov			Elevate causeway
0800	2.0 (0.61)	12.2	
1200	1.6 (0.49)	10.5	
1600	2.6 (0.79)	11.4	
14 Nov			Elevate causeway
0800	1.8 (0.55)	12.2	
1200	1.5 (0.46)	12.2	
1600	2.0 (0.61)	12.9	
17 Nov			Elevate causeway
0800	4.9 (1.49)	14.1	
1200	5.4 (1.65)	12.4	
1600	6.7 (2.04)	10.3	
18 Nov			Elevate causeway
0800	6.9 (2.10)	9.2	
1200	5.7 (1.74)	10.8	
1600	5.7 (1.74)	11.9	
19 Nov			Elevate causeway
0800	3.4 (1.04)	11.6	
1200	3.0 (0.91)	11.1	
1600	2.3 (0.70)	9.2	
20 Nov			Elevate causeway, first Lo/Ro test
0800	1.5 (0.46)	11.0	
1200	1.6 (0.49)	14.7	
1600	1.5 (0.46)	12.8	
21 Nov			Elevate causeway, unstuffing 20-ton (18,000-kg) container at beach
0800	3.0 (0.91)	15.3	
1200	3.9 (1.19)	15.0	
1600	4.3 (1.31)	14.6	
22 Nov			Elevate causeway
0800	2.3 (0.70)	12.2	
1200	2.5 (0.76)	12.2	
1600	3.0 (0.91)	10.5	

continued

Table B-4. Continued

Date/Time	Height[b] (ft, m)	Period (sec)	Test Activity
23 Nov			Complete elevation of causeway
0800	2.5 (0.76)	11.6	
1200	2.4 (0.73)	12.7	
1600	2.5 (0.76)	16.7	
24 Nov			Install fender
0800	5.1 (1.55)	13.8	
1200	3.6 (1.10)	12.6	
1600	2.8 (0.85)	14.4	
25 Nov			Drive fender piles
0800	2.6 (0.79)	13.5	
1200	3.4 (1.04)	13.3	
1600	3.3 (1.01)	15.3	
26 Nov			Install exterior spudwells on Section 10
0800	4.8 (1.46)	14.0	
1200	5.3 (1.62)	12.0	
1600	3.9 (1.19)	12.4	
27 Nov			
0800	3.0 (0.91)	14.3	
1200	4.8 (1.46)	13.3	
1600	3.9 (1.19)	14.8	
1 Dec			Install container crane on pier
0800	–	–	
1200	1.5 (0.46)	14.2	
1600	1.5 (0.46)	14.7	
2 Dec			Load/unload causeway ferry
0800	1.6 (0.49)	16.2	
1200	1.8 (0.55)	14.6	
1600	–	–	
3 Dec			Load/unload LCM-8 and LCU
0800	–	–	
1200	1.7 (0.52)	11.8	
1600	–	–	
4 Dec			Load/unload LCU, second Lo/Ro test, fender impact test
0800	–	–	
1200	1.6 (0.49)	7.2	
1600	–	–	
5 Dec			Load/unload causeway ferry
0800	2.3 (0.70)	13.6	
1200	–	–	
1600	–	–	

continued

Table B-4. Continued

Date/Time	Height[b] (ft, m)	Period (sec)	Test Activity
6 Jan 76			Remove causeway
0800	2.8 (0.85)	9.4	
1200	2.3 (0.70)	7.6	
1600	3.3 (1.01)	8.9	
7 Jan			Remove causeway
0800	2.6 (0.79)	8.9	
1200	3.3 (1.01)	10.3	
1600	3.0 (0.91)	10.9	
8 Jan			Remove causeway
0800	2.4 (0.73)	12.1	
1200	3.4 (1.04)	10.9	
1600	2.7 (0.82)	12.6	
9 Jan			Remove causeway
0800	2.1 (0.64)	12.3	
1200	–	–	
1600	–	–	

[a]Water depth at buoy location was approximately 25 feet (7.6 m).

[b]Maximum recorded height in 10-minute period beginning at indicated hour.

Table B-5. Waves Near Shore at Coronado Test Site

Date/Time	Breaker Height (ft, m)	Dominant Period (sec)	Breaker Direction[a] (deg)	No. of Lines of Breakers	Test Activity
12 Nov					Beach causeway
0800	2.0-3.0 (0.61-0.91)	13.5	0	3	
0900	2.0-3.0 (0.61-0.91)	13.0	0	3	
1100	2.0-3.5 (0.61-1.07)	11.0	5(R)	1-2	
1300	1.5-2.5 (0.46-0.76)	12.5	0	3	
1500	1.5-2.5 (0.46-0.76)	14.0	0	3	
13 Nov					Elevate causeway
0800	2.0-2.5 (0.61-0.76)	10.0	0	1-2	
0900	1.0-1.5 (0.30-0.46)	11.0	0	2	
1100	1.5-2.5 (0.46-0.76)	10.0	5(R)	1-2	
1500	2.5-3.5 (0.76-1.07)	15.0	5(R)	1-2	
1600	1.0-2.0 (0.30-0.61)	8.0	–	4-5	
14 Nov					Elevate causeway
1000	1.0-2.5 (0.30-0.76)	13.0	0	2	
17 Nov					Elevate causeway
0800	3.5-5.5 (1.07-1.68)	10.0	15(L)	2-3	
1000	2.0-4.5 (0.61-1.37)	10.5	0	2-3	
1200	4.0-5.0 (1.22-1.52)	10.0	5(L)	2-3	
1530	3.0-3.5 (0.91-1.07)	10.0	5(L)	2-3	
18 Nov					Elevate causeway
0800	3.5-5.0 (1.07-1.52)	11.0	0	2-4	
1000	3.0-5.0 (0.91-1.52)	9.0	0	2-4	
1600	2.0-2.5 (0.61-0.76)	11.0	0	2-3	
21 Nov					Elevate causeway, unstuffing 20-ton (18,000-kg) container at beach
0800	2.0-3.5 (0.61-1.07)	15.0	5(L)	1-2	
0900	1.0-2.5 (0.30-0.76)	15.0	0	1-2	
1200	1.5-3.0 (0.46-0.91)	15.5	0	1-2	
24 Nov					Install fender
0800	1.0-2.5 (0.30-0.76)	14.0	0	1-2	
0900	1.5-3.0 (0.46-0.91)	14.0	0	1-2	
2 Dec					Load/unload causeway ferry
0900	0.5-1.0 (0.15-0.30)	14.0	0	1	
3 Dec					Load/unload LCM-8 and LCU
0800	0.5-1.5 (0.15-0.46)	9.0	10(R)	1	
4 Dec					Load/unload LCU, second Lo/Ro test, fender impact test
0800	1.0-2.5 (0.30-0.76)	9.0	15(R)	1	
5 Dec					Load/unload causeway ferry
0800	0.5-1.0 (0.15-0.30)	12.5	15(R)	1	

[a]Acute angle between breaker crest and shoreline. An R or L after entry means breaker advances toward right (or left) flank as seen from seaward.

Table B-6. Climatic Data Summary for Coronado Test Site[a]

Date/Time	Wind Direction (deg)	Wind Speed (kt, m/sec)	Air Temperature (°F, °C)	Visibility (mi, km)	Weather and Obstruction to Visibility	Test Activity
12 Nov						Beach causeway
0800	150	2 (1.0)	59 (15.0)	30 (48.3)		
1200	300	4 (2.1)	81 (27.2)	25 (40.2)		
1600	330	11 (5.7)	75 (23.9)	25 (40.2)		
13 Nov						Elevate causeway
0800	–	0 (0.0)	63 (17.2)	35 (56.3)		
1200	360	5 (2.6)	84 (28.9)	20 (32.2)		
1600	330	3 (1.5)	79 (26.1)	20 (32.2)		
14 Nov						Elevate causeway
0800	360	2 (1.0)	62 (16.7)	15 (24.1)		
1200	200	6 (3.1)	72 (22.2)	15 (24.1)		
1600	300	2 (1.0)	66 (18.9)	20 (32.2)		
15 Nov						
0800	–	0 (0.0)	56 (13.3)	15 (24.1)		
1200	280	6 (3.1)	68 (20.0)	15 (24.1)		
1600	320	7 (3.6)	62 (16.7)	7 (11.3)		
16 Nov						
0800	100	2 (1.0)	53 (11.7)	1.5 (2.4)	ground fog	
1200	290	7 (3.6)	62 (16.7)	7 (11.3)		
1600	290	7 (3.6)	58 (14.4)	7 (11.3)		
17 Nov						Elevate causeway
0800	090	1 (0.5)	55 (12.8)	5 (8.0)	haze	
1200	190	6 (3.1)	58 (14.4)	7 (11.3)		
1600	250	8 (4.1)	59 (15.0)	10 (16.1)		
18 Nov						Elevate causeway
0800	140	6 (3.1)	56 (13.3)	15 (24.1)		
1200	240	6 (3.1)	60 (15.6)	20 (32.2)		
1600	300	7 (3.6)	58 (14.4)	20 (32.2)		
19 Nov						Elevate causeway
0800	050	2 (1.0)	52 (11.1)	20+ (32.2+)		
1200	300	7 (3.6)	64 (17.8)	25+ (40.2+)		
1600	320	13 (6.7)	62 (16.7)	25 (40.2)		
20 Nov						Elevate causeway, first Lo/Ro test
0800	–	0 (0.0)	54 (12.2)	30+ (48.3+)		
1200	300	8 (4.1)	61 (16.1)	20 (32.2)		
1600	320	7 (3.6)	60 (15.6)	15 (24.1)		
21 Nov						Elevate causeway, unstuffing 20-ton (18,100 kg) container at beach
0800	–	0 (0.0)	55 (12.8)	12 (19.3)		
1200	310	9 (4.6)	62 (16.7)	10 (16.1)		
1600	320	10 (5.1)	61 (16.1)	10 (16.1)		
22 Nov						Elevate causeway
0800	340	3 (1.5)	56 (13.3)	25 (40.2)		
1200	290	5 (2.6)	69 (20.6)	25 (40.2)		
1600	340	13 (6.7)	63 (17.2)	25 (40.2)		

continued

Table B-6. Continued

Date/Time	Wind		Air Temperature (^oF, ^oC)	Visibility (mi, km)	Weather and Obstruction to Visibility	Test Activity
	Direction (deg)	Speed (kt, m/sec)				
23 Nov						Complete elevation of causeway
0800	310	5 (2.6)	50 (10.0)	15 (24.1)		
1200	330	12 (6.2)	71 (21.7)	20 (32.2)		
1600	150	4 (2.1)	65 (18.3)	20 (32.2)		
24 Nov						Install fender
0800	–	0 (0.0)	57 (13.9)	25 (40.2)		
1200	290	8 (4.1)	78 (25.6)	25 (40.2)		
1600	300	9 (4.6)	73 (22.8)	25 (40.2)		
25 Nov						Drive fender piles
0800	340	2 (1.0)	57 (13.9)	20 (32.2)		
1200	210	3 (1.5)	65 (18.3)	15 (24.1)		
1600	–	0 (0.0)	60 (15.6)	10 (16.1)		
26 Nov						Install exterior spudwells on Section 10
0800	220	2 (1.0)	58 (14.4)	10 (16.1)		
1200	210	4 (2.1)	65 (18.3)	15 (24.1)		
1600	200	7 (3.6)	60 (15.6)	15 (24.1)		
27 Nov						
0800	230	8 (4.1)	56 (13.3)	7 (11.3)		
1200	220	9 (4.6)	57 (13.9)	7 (11.3)		
1600	230	13 (6.7)	55 (12.8)	7 (11.3)		
28 Nov						
0800	250	12 (6.2)	54 (12.2)	15 (24.1)		
1200	250	18 (9.3)	56 (13.3)	20 (32.2)		
1600	260	10 (5.1)	51 (10.6)	20 (32.2)	light rain	
29 Nov						
0800	300	7 (3.6)	53 (11.7)	15 (24.1)		
1200	230	6 (3.1)	57 (13.9)	15 (24.1)		
1600	250	5 (2.6)	54 (12.2)	15 (24.1)		
30 Nov						
0800	–	0 (0.0)	46 (7.8)	25 (40.2)		
1200	310	8 (4.1)	57 (13.9)	20 (32.2)		
1600	320	10 (5.1)	55 (12.8)	20 (32.2)		
1 Dec						Install container crane on pier
0800	–	0 (0.0)	52 (11.1)	45 (72.4)		
1200	330	6 (3.1)	67 (19.4)	20 (32.2)		
1600	330	6 (3.1)	57 (13.9)	20 (32.2)		
2 Dec						Load/unload causeway ferry
0800	–	0 (0.0)	57 (13.9)	25 (40.2)		
1200	200	5 (2.6)	61 (16.1)	25 (40.2)		
1600	180	7 (3.6)	58 (14.4)	20 (32.2)		
3 Dec						Load/unload LCM-8 and LCU
0800	020	2 (1.0)	53 (11.7)	10 (16.1)		
1200	230	9 (4.6)	57 (13.9)	7 (11.3)		
1600	180	2 (1.0)	55 (12.8)	6 (9.7)	haze	

continued

Table B-6. Continued

Date/Time	Wind		Air Temperature (°F, °C)	Visibility (mi, km)	Weather and Obstruction to Visibility	Test Activity
	Direction (deg)	Speed (kt, m/sec)				
4 Dec						Load/unload LCU, second Lo/Ro test, fender impact test
0800	060	5 (2.6)	53 (11.7)	3 (4.8)	fog/haze	
1200	210	6 (3.1)	56 (13.3)	7 (11.3)		
1600	220	4 (2.1)	55 (12.8)	7 (11.3)		
5 Dec						Load/unload causeway ferry
0800	310	4 (2.1)	54 (12.2)	6 (9.7)	haze	
1200	310	6 (3.1)	59 (15.0)	5 (8.0)	haze	
1600	320	10 (5.1)	56 (13.3)	5 (8.0)	haze	
5 Jan 76						Remove fender, begin causeway removal
0800	–	0 (0.0)	49 (9.4)	10 (16.1)		
1200	210	7 (3.6)	57 (13.9)	10 (16.1)		
1600	270	5 (2.6)	59 (15.0)	10 (16.1)		
6 Jan						Remove causeway
0800	–	0 (0.0)	48 (8.9)	10 (16.1)		
1200	280	7 (3.6)	57 (13.9)	7 (11.3)		
1600	310	7 (3.6)	56 (13.3)	7 (11.3)		
7 Jan						Remove causeway
0800	–	0 (0.0)	48 (8.9)	6 (9.7)	haze/smoke	
1200	340	7 (3.6)	67 (19.4)	15 (24.1)		
1600	340	10 (5.1)	62 (16.7)	20 (32.2)		
8 Jan						Remove causeway
0800	100	4 (2.1)	52 (11.1)	15 (24.1)		
1200	310	8 (4.1)	66 (18.9)	15+ (24.1+)		
1600	330	8 (4.1)	62 (16.7)	15 (24.1)		
9 Jan						Remove causeway
0800	280	2 (1.0)	47 (8.3)	6 (9.7)	haze	
1200	170	2 (1.0)	57 (13.9)	5 (8.0)	haze	
1600	270	7 (3.6)	56 (13.3)	10 (16.1)		
10 Jan						Remove causeway, causeway off beach at 1312
0800	110	1 (0.5)	53 (11.7)	25 (40.2)		
1200	320	4 (2.1)	57 (13.9)	20 (32.2)		
1600	300	10 (5.1)	57 (13.9)	25 (40.2)		

[a]Observations made by Naval Weather Service Facility at North Island. Weather station is located approximately 3 miles (4.8 km) from the Coronado test site.

Appendix C

HUMAN FACTORS STUDY

BACKGROUND

This appendix presents the results of a human factors study of the COTS pier construction and container off-loading and transfer operations conducted at Coronado, California, by PHIBCB-ONE and CEL during November and December 1975. The study reported herein was performed by personnel from the Human Factors Division of the Naval Electronics Laboratory Center.

NELC observed operations and collected human factors data during COTS Engineering Tests conducted by CEL at Point Mugu in June and July 1975. Participation in the Point Mugu tests enabled the study team to become familiar with the COTS system and pier construction activities and to develop and evaluate data collection techniques for the Coronado tests. Operational procedures for pier construction activities as observed at Point Mugu were documented and submitted to CEL in March 1975; these procedures are included in Volume II. A panel layout study of the jacking system power control unit was performed prior to the Point Mugu tests and validated during these tests. The panel layout study was re-evaluated and modified on the basis of observations during the Coronado pier construction operations and is included in Volume II.

OBJECTIVE

The objective of the study was to identify man and equipment problems in COTS pier construction and container off-loading and transfer operations and to develop improvements in the man/equipment interface and personnel requirements in terms of numbers and skill levels. These data were obtained by direct observation and video tape recordings of the operations. While emphasis was given to personnel requirements and utilization, pier construction methods and equipment were also examined since these and personnel actions are interdependent. Potential or actual hazard areas for personnel and equipment were also identified and means for eliminating or minimizing them are presented. The study scope was limited to pier construction and container off-loading and transfer activities. Specifically excluded were staging area operations, pier transport to beach site, warping tug activities, and beach activities, because it was felt that these would vary from one operation to another.

CONCLUSIONS AND RECOMMENDATIONS

The COTS pier construction and container off-loading and transfer operations could be improved through better utilization of personnel and changes in methods and equipment. Hazards to personnel and potential damage to equipment can also be eliminated or minimized through changes in the methods used, introduction of safety devices, development of standard procedures, and increasing the safety consciousness on the part of all personnel. The identified problems and their possible solutions are presented in Volume II on a task-by-task basis.

A restructuring of the jack rigging activities through augmentation and better utilization of personnel/equipment could significantly increase the pier construction rate; the solution to this problem is presented in Volume II in the form of multiple activity charts that describe work sequencing for various combinations of four-man jack rigging teams and jacks.

Alternatives to the gimbal and pile cap schemes for attaching causeway sections are recommended to reduce personnel and equipment requirements, task times, safety hazards, and equipment damage potential.

Transport of the causeway sections with prepositioned vertical piles is recommended to speed up pier construction time as well as to reduce personnel and equipment requirements. Some means of connecting these piles to the spudwells in lieu of welding should be investigated for the same reasons.

Many of the problems identified would be

aggravated by more severe environmental conditions in terms of sea state, wind, temperature, etc. At Coronado, the environmental conditions were close to ideal. Although noise from various sources was noted, its effect on verbal person-to-person communications was not investigated. This should be performed at the next opportunity to assure adequate communications between personnel during pier construction and container off-loading and transfer activities.

It is felt that the benefits that should be realized through the adoption of these and other recommendations could be more than offset by shortcomings in the areas of personnel training, operations planning, organization, and establishment and adherence to a chain of command for decisions and direction during pier construction.

DISTRIBUTION LIST

AFB AUL/LSE 63-465, Maxwell AL, CESCH, Wright-Patterson
ARMY BALLISTIC RSCH LABS AMXBR-XA-LB, Aberdeen Proving Ground MD
ARMY DEV READINESS COM AMCPM-CS (J. Carr), Alexandria VA
ARMY MATERIALS & MECHANICS RESEARCH CENTER Dr. Lenoe, Watertown MA
ARMY MOBIL EQUIP R&D COM Mr. Cevasco, Fort Belvoir MD
ASST SECRETARY OF THE NAVY Spec. Assist Energy (P. Waterman), Washington DC
MCB ENS S.D. Keisling, Quantico VA
CNO Code NOP-964, Washington DC
COMCBPAC Operations Off, Makalapa HI
COMNAVMARIANAS Code N4, Guam, FCE, Guam
COMSUBDEVGRUONE Operations Offr, San Diego, CA
DEFENSE DOCUMENTATION CTR Alexandria, VA
DNA STTL, Washington DC
MARINE CORPS BASE PWO, Camp S. D. Butler, Kawasaki Japan
MARINE CORPS DIST 9, Code 043, Overland Park KS
MCAS Code PWE, Kaneohe Bay HI, PWO
MILITARY SEALIFT COMMAND Washington DC
NATL RESEARCH COUNCIL Naval Studies Board, Washington DC
NAVAL FACILITY PWO, Centerville Bch, Ferndale CA
NAVCOASTSYSLAB CO, Panama City FL, Code 710.5 (J. Quirk), Library
NAVCONSTRACEN Code N-41, Port Hueneme CA
NAVEODFAC Code 605, Indian Head MD
NAVFACENGCOM Code 0433B, Code 0453 (D. Potter), Code 04B5, Code 101, Code 104, Code 2014 (Mr. Taam), Pearl Harbor HI, PC-22 (E. Spencer), PL-2
NAVFACENGCOM - CHES DIV. Code FPO-1 (Ottsen)
NAVFACENGCOM - LANT DIV. RDT&ELO 09P2, Norfolk VA
NAVFACENGCOM - NORTH DIV. Code 1028, RDT&ELO, Philadelphia PA
NAVFACENGCOM - PAC DIV. Code 402, RDT&E, Pearl Harbor HI, Commanders
NAVFACENGCOM - WEST DIV. Codes 09PA, 09P/20
NAVFORCARIB Commander (N42), Puerto Rico
NAVMARCORESTRANCEN ORU 1118 (Cdr D.R. Lawson), Denver CO
NAVOCEANO Code 1600
NAVPGSCOL Code 2124 (Library), Monterey CA, D. Leipper, Monterey CA, E. Thornton, Monterey CA
NAVPHIBASE Code S3T, Norfolk VA, Dir. Amphib. Warfare Brd Staff, OIC, UCT I
NAVSEASYSCOM Code SEA OOC
NAVSEC Code 6034 (Library), Washington DC
NAVSHIPYD Code 202.5 (Library) Puget Sound, Bremerton WA, PWD (LT N.B. Hall), Long Beach CA
NAVSUPPACT AROICC (LT R.G. Hocker), Naples Italy
NAVTRAEQUIPCEN Technical Library, Orlando FL
NAVWPNSUPPCEN PWO
NCBC CEL (CDR N.W. Petersen), Port Hueneme, CA, Code 10
NCR 20, Commander
NMCB 5, Operations Dept., 74, CO, One, LT F.P. Digeorge
NROTCU Univ Colorado (LT D R Burns), Boulder CO
NTC Code 54 (ENS P. G. Jackel), Orlando FL, OICC, CBU-401, Great Lakes IL
NUC Code 409 (D. G. Moore), San Diego CA, Code 65 (H. Talkington), Code 65402 (R. Jones), Code 6565 (Tech. Lib.), San Diego CA
OCEANAV Mangmt Info Div., Arlington VA
OFFICE OF NAVAL RESEARCH CDR Harlett, Boston MA
ONR Dr. A. Laufer, Pasadena CA
PMTC Pat. Counsel, Point Mugu CA
PWC ENS J.A. Squatrito, San Francisco Bay, Oakland CA, OIC CBU-405, San Diego CA
USCG R&D CENTER D. Motherway, Groton CT, Tech. Dir.
USNA Ch. Mech. Engr. Dept, Sys. Engr Dept (Dr. Monney), Annapolis MD
CALIFORNIA INSTITUTE OF TECHNOLOGY Pasadena CA (Keck Ref. Rm)
ENERGY R&D ADMIN. Dr. Cohen

FLORIDA ATLANTIC UNIVERSITY BOCA RATON, FL (MC ALLISTER)
IOWA STATE UNIVERSITY Ames IA (CE Dept, Handy)
LEHIGH UNIVERSITY Bethlehem PA (Linderman Lib. No.30, Flecksteiner)
LIBRARY OF CONGRESS WASHINGTON, DC (SCIENCES & TECH DIV)
MASSACHUSETTS INST. OF TECHNOLOGY Cambridge MA (Rm 10-500, Tech. Reports, Engr. Lib.), Cambridge MA (Rm 14 E210, Tech. Report Lib.)
MICHIGAN TECHNOLOGICAL UNIVERSITY HOUGHTON, MI (HAAS)
PURDUE UNIVERSITY LAFAYETTE, IN (ALTSCHAEFFL)
TEXAS A&M UNIVERSITY COLLEGE STATION, TX (CE DEPT), College TX (CE Dept, Herbich)
UNIVERSITY OF CALIFORNIA BERKELEY, CA (OFF. BUS. AND FINANCE, SAUNDERS)
UNIVERSITY OF DELAWARE Newark, DE (Dept of Civil Engineering, Chesson)
UNIVERSITY OF HAWAII HONOLULU, HI (SCIENCE AND TECH. DIV.)
UNIVERSITY OF MASSACHUSETTS (Heronemus), Amherst MA CE Dept
UNIVERSITY OF MICHIGAN Ann Arbor MI (Richart)
UNIVERSITY OF WASHINGTON SEATTLE, WA (OCEAN ENG RSCH LAB, GRAY)
URS RESEARCH CO. LIBRARY SAN MATEO, CA
ATLANTIC RICHFIELD CO. DALLAS, TX (SMITH)
AUSTRALIA Dept. PW (A. Hicks), Melbourne
BECHTEL CORP. SAN FRANCISCO, CA (PHELPS)
BELGIUM NAECON, N.V., GEN.
CANADA Mem Univ Newfoundland (Chari), St Johns, Surveyor, Nenninger & Chenevert Inc..
DILINGHAM PRECAST F. McHale, Honolulu HI
DRAVO CORP Pittsburgh PA (Giannino)
FRANCE Pierre Launay, Boulogne-Billancourt
MARATHON OIL CO Houston TX (C. Seay)
MC CLELLAND ENGINEERS INC Houston TX (B. McClelland)
NORWAY J. Creed, Ski, Norwegian Tech Univ (Brandtzaeg), Trondheim
PACIFIC MARINE TECHNOLOGY LONG BEACH, CA (WAGNER)
PORTLAND CEMENT ASSOC. SKOKIE, IL (COREI.Y). Skokie IL (Rsch & Dev Lab, Lib.)
SEATECH CORP. MIAMI, FL (PERONI)
SHELL OIL CO. Houston TX (R. de Castongrene)
SWEDEN VBB (Library), Stockholm
UNITED KINGDOM Cement & Concrete Assoc. (Lit. Ex), Bucks, Cement & Concrete Assoc. (R. Rowe), Wexham Springs, Slough Bucks, D. New, G. Maunsell & Partners, London, Taylor, Woodrow Constr (014P), Southall, Middlesex
WESTINGHOUSE ELECTRIC CORP. Annapolis MD (Oceanic Div Lib, Bryan)
WOODWARD-CLYDE CONSULTANTS Dr. J. Gaffey, Orange CA, PLYMOUTH MEETING PA (CROSS, III)

ATE

LME